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The Earth
Under a Stormy Sun

Technology Review

Edited at the Massachusetts Institute of Technology

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* * *

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First Line

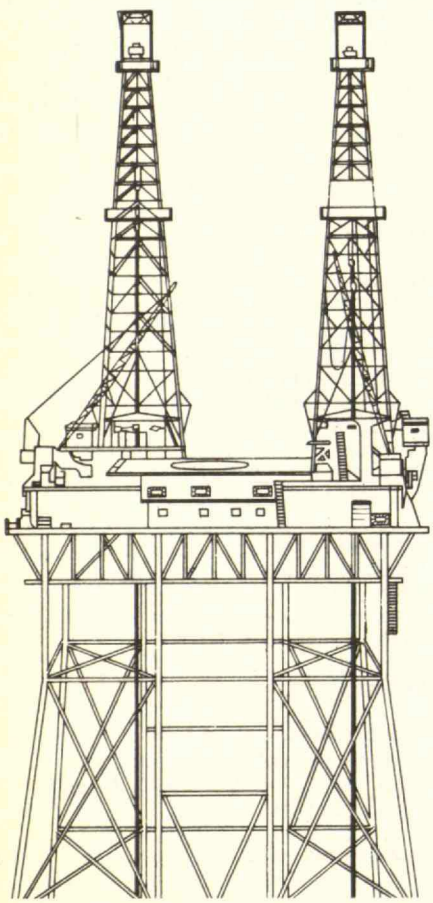
The Cover

Though to the casual observer our nearest star may seem a constant, steadfast source of light and heat, it is in fact a turbulent, seething nuclear reactor whose behavior is as yet little understood. The cover photograph is one of some 183,000 photographic exposures of the sun made by solar telescopes on Skylab during 1973. It shows a remarkable eruption of relatively dense low-temperature material from the sun into the overlying corona — one of many hundreds of solar phenomena hardly known to exist before Skylab, a product of forces which remain essentially mysterious.

On the scale of the photograph as reproduced on our cover, the earth would appear as a speck no larger than the head of a pin.

Next Month: Offshore Oil

What fruits and dangers await us as exploration begins off the U.S. east coast for oil on the outercontinental shelves? To this question will be devoted our entire major editorial content in the February issue: how much oil there may be, what will be its impact on the U.S. economy and the world oil market, and what is its potential for ecological hazard.



Letters

How's That Again?

In the July/August issue of the *Review* are two articles bordering on science fiction. "Is There an Airship in Your Future?" by Joseph F. Vittek, Jr. (*pp. 22-29*) plays down the two major reasons that large airships are impractical and dangerous:

1. The impossibility of sufficient structural strength to withstand violent weather together with the necessary light weight.
2. The well-nigh insoluble problems involved in handling and storage on the ground.

The author mentions only the 13 paying passengers lost in the Hindenberg disaster. The actual toll was 36. Over 200 were lost in crashes due to structural failure of five of the latest and largest post-World War I airships. Most of these crashed in less than a year after launching. This accident record indicates airship travel to have been one of the most dangerous methods yet devised by man. I quote without comment Dr. Vittek's statement regarding the many airships lost in weather-related crashes: "In almost every case the design was more than able to survive anticipated weather — the problem was that the weather encountered was much worse than anticipated."

Timothy M. Barrows' "Suspension Concepts for High-Speed Ground Transportation" (*pp. 30-41*) stretches one's credibility, as well. The well-nigh prohibitive costs of the suggested guideways is passed off with the suggestion that "capital-intensive" systems are now the order of the day. But one look at the guideways suggested shows them to be useless in climates where snow, ice, or heavy rain occur, and many of them appear to invite serious accidents from anything falling into the guideway. I suggest that Dr. Barrows return to his drawing board to invent the steel rail and wheel, the most economical and reliable all-weather system of travel yet devised.

C. F. Taylor
Cambridge, Mass.

Dr. Taylor is Professor of Automotive Engineering, Emeritus at M.I.T.

Displaced Miners

Re: "The Transition to Coal" (*October/November, pp. 18-29*). The principal costs of producing electric energy at any electric utility power plant are capital amortization and fuel. The combination of a 13 per cent amortization rate and a 60 per cent load factor gives a capital cost of approximately .25 cents per kwh. for each $100 per kw. plant capacity. Current plant costs approximate $400 per kw. for coal-fired plants and $800 per kw. for light-water nuclear plants, thus giving one and two cents per kwh. capital costs, respectively.

The current cost of uranium approximates 25 cents per million B.t.u. The conversion of B.t.u. to kwh. occurs at approximately 32.5 per cent efficiency, thus requiring 10,500 B.t.u. per kwh. or a fuel cost of approximately .25 cents per kwh. The total plant energy generating cost is 2.25 cents per kwh. for uranium-fired light-water plants.

In order to compete, coal-fired plants with one cent per kwh. capital cost must hold fuel cost to 1.25 cents per kwh. An efficient coal-fired plant expends approximately 9,000 B.t.u. per kwh. produced. Therefore, using coal with 27 million B.t.u. per ton of thermal content, the coal cost must not exceed $37.50 per ton in order to be competitive.

Obviously, with coal costs being driven up into the $100-per-ton area by wage demands, we may expect an accelerated coal plant displacement by nuclear plants with subsequent reduction of over 50 per cent in our coal demand.

Raymond Mancha
Winter Park, Fla.

A Question Solved

The basic premise of "Some Unsolved Puzzles of Chlorinated Hydrocarbons" (*February, p. 13*) is true: there is much we don't know, and we poorly understand what we do know. But there is a rather glaring error in the discussion of sediment sequestering and equilibriums. Dr. Nisbet states that "recent measurements in the Great Lakes suggest . . . concentrations of pesticides and PCBs have remained high and there seems to be a rough equilibrium between levels in sediments, water, and biota." The inference is that levels are remaining high even though the inputs have been eliminated.

Yet, following the ban of DDT in the Lake Michigan watershed in 1969-70, the levels of DDT and its metabolites declined drastically in samples of fish from the lake. It is true that PCBs and dieldrin have remained high in Lake Michigan fishes, but it is also apparent that the sources of these materials to the lake have not been eliminated. Further evidence that levels of contaminants in the biota (fish) of the Great Lakes will decline following elimination of sources is the rapid decline of mercury residues in fish from Lake St. Clair after the reduction of mercury inputs in the area in 1970.

I believe that permanent sequestering in the sediments is the primary mechanism by which the Great Lakes cleanse themselves following the control of contaminant inputs such as DDT. And I think much more is known about the fate of "chlorinated hydrocarbons" in aquatic systems than was inferred in the article.

Wayne A. Willford
Ann Arbor, Mich.

Mr. Willford is Chief, Section of Physiology and Contaminant Chemistry at the Great Lakes Fishery Laboratory, U.S. Fish and Wildlife Service.

Inflation and the Social Contract

Technology/Society
by
Kenneth E. Boulding

Our inability to achieve full employment without inflation is one of the most distressing failures of economic theory and practice in the past generation. Inflation is a world disease. In the last 30 years, no country has been exempt — not even the centrally-planned economies — with the possible exception of mainland China. A constant rate of inflation of, say, under five per cent per annum is easy to tolerate. It amounts to little more than a small tax on idle money, and to some extent on pensions and bonds, though they may escape as nominal interest rates rise to compensate, and as social security payments, for example, are adjusted upwards. A steady 10 per cent inflation is profoundly uncomfortable, and 20 per cent is disrupting. So accelerating inflation, such as most developed countries have experienced in the last two or three years, is unacceptable. If it continues for very long, it will lead to serious economic breakdown and even to hyperinflation as in 1923 Germany and 1946 Hungary.

Unemployment, Inflation, or . . .

The mild inflation that the U.S. has enjoyed (and I use the word advisedly) in the past 30 years is accelerating to an uncomfortable level. Canada and many European countries are in even worse shape. Why has this happened? We may blame the oil monopoly for some of it. The price of wheat rose about as much as the price of oil, which eased the United States' balance of payments problem but did little to allay world inflation.

The real trouble lies much deeper. In the 19th and early 20th centuries, a long-run stability in prices was achieved, but at the cost of large, 60-year fluctuations, long deflations and unemployment, and missed opportunities for growth. This occurred chiefly because of the inflexibility in the money supply imposed by the gold, and, to a lesser extent, the silver standards. Since 1945, inspired partly by the success of Keynesian doctrines, no nation has been willing to pay that cost for price stability. When there is a choice between unemployment and inflation, we always seem to choose inflation. That decision is probably reasonable when the rate of inflation is low and stable. When the rate becomes high and accelerating, the cost of price instability rises. We then come to a point at which *all* alternatives seem very expensive, and a desperate search for a viable policy is in order. We are alarmingly close to that point now.

To find this policy of full employment without unacceptable inflation, we must understand the sources of the dilemma. Inflation is not merely the result of monopoly power, either of labor unions or of corporations, for inflationary pressure sometimes originates in the organized competitive commodity markets. It is not merely the result of increase in the money supply, due either to government cash deficits or expanding bank loans, though this is an almost essential part of the mechanism. Expansion of the money supply may be the inevitable response to a previous spontaneous increase in money-wages and prices. Further, unemployment — so often inspiring inflationary measures — is in part structural, caused by a legal minimum wage, or lack of skills, or a failure of specific types of labor by age, sex, culture, or skill to match types of demand for labor. Monetary expansion will *not* diminish structural unemployment. One suspects that part of our problem today is that structural unemployment has been increasing, perhaps because of increasing legal intervention in labor markets.

Balking at Belt-Tightening

Moving still deeper, one sees the sheer psychological difficulty of reducing any money-wages or prices where this is perceived as being done by an employer or a purchaser rather than by an impersonal market. If no money-wage or price can be lowered, however, the only way in which relative prices and wages can be changed — a constant necessity in an age of rapid relative technological change — is by raising some money-wages and prices and stabilizing the rest, which means overall inflation. This may be a more important factor in long-run inflation than the actual exercise of monopoly power. Indeed, in wartime inflation or any inflation originating in government cash deficits, collective bargaining has often held wages and prices down simply because of the time and palaver involved in such bargaining. During World War II in the United States, union wages doubled and non-union wages roughly quadrupled! But if nothing can be lowered, everything must rise.

A Phony Bargain

At a still more fundamental level, the price-wage structure represents an implicit social contract to divide the available product. If everybody wants more than his share, the only course is to increase the dollar value of the product by inflation. This produces a dynamic jockeying as first one group and then another gets the initial but soon eroded benefits of a rise in money-wages or in the price of their product. In this the poor, the women, the young, the minorities, and the aged are apt to lose out, and the implicit social contract is reestablished at the expense of the weak. Collective bargaining is partly to blame here, simply because it is so often a phony bargain. What labor, for instance, gains in wages is not at the employer-bargainer's expense, but at the expense of those who must pay a higher price for the product, and who are not at the bargaining table. Collective bargaining, with all its contributions to industrial jurisprudence, is also a system of taxation without representation, and its institutions need re-examining in the light of this serious defect.

Government deficits can also be regarded as a breakdown in the social contract, insofar as they imply that we are not willing to suffer the reduction of consumption through taxation which would compensate for the increase through government expenditure. This again means we all want more than there is — and inflation is the fudge that gives a phony increase.

Kenneth E. Boulding is Professor of Economics and Director of the Institute of Behavioral Science at the University of Colorado.

Quarantining Plutonium

National Report
by
David F. Salisbury

The large truck looked quite ordinary.

But this particular truck was specially-outfitted by Sandia Laboratories of Albuquerque, N.M., to transport strategic nuclear materials — the stuff of which atomic bombs are made.

Sandia has for many years designed security systems for nuclear weapons. Since 1973, it has received increasing amounts of government money to apply this experience to the problems of transporting fissionable materials in the nuclear energy industry.

The International Atomic Energy Agency (I.A.E.A.) estimates that by the year 2000, enough plutonium will be created in commercial nuclear reactors each year to make 100,000 atomic bombs. Although this figure may be too large, it does suggest the vast amount of strategic nuclear materials that nations and people must guard and handle. All this plutonium must be protected somehow from unstable national leaders and kept out of the hands of would-be nuclear terrorists. (Rumor has it that Libya is in the market for a nuclear bomb.)

A Super-Truck for Super-Cargo

Sandia's safeguard truck is one important piece in the jigsaw puzzle of a tight security system slowly being pieced together in the U.S. According to Dr. Theodore Taylor, the nuclear weapons expert who has emerged as the best informed of the crusaders for tighter safeguards, the most vulnerable link in the security system is transportation.

This truck's special virtues were described to me recently by Robert Reed, staff member of Sandia's Transportation Division:

— Walls of its cargo bay are built of a classified, penetration-resistant material.

— Cargo doors are multiple-leafed and designed so they cannot be removed even if the outside hinges are cut.

— Inside the armored car is an electronic lock which takes four hours to pick; it has a million combinations. The driver does not know the combination for his own safety.

— The driver can pull a panic lever. Once he does, and the truck slows down below a certain speed, the wheels lock permanently: no driving the truck to some secluded spot where the thieves can work in peace. At the same time, the truck's radio begins to broadcast a special alarm signal.

— If the attackers should manage to break into the cargo compartment, more surprises await them. An automatic security system fills the compartment with a fast-setting plastic foam and releases a powerful anti-personnel gas.

Foam may not seem a substantial barrier, but Sandia has film clips of a U.S. Army ordinance team attempting to break into an underground igloo filled with a mixture of foam and bedsprings. Although the energetic soldiers tried chainsaws, blow torches, scoop loaders, and high explosives, they penetrated only 14 feet in 14 hours. Even with the explosives,

their fastest progress was two feet an hour.

Nonetheless, a barrier is not enough; a reliable communications system is also necessary. Sandia has been working in this area, as well, but its progress has not been dramatic. Today drivers carrying nuclear materials call in their position and status every half-hour by radiotelephone. Atmospheric conditions periodically interfere, and the control center can handle less than ten shipments at a time.

Now a digital system of Sandia's design is being installed. It will allow the Energy Research and Development Administration (E.R.D.A.) to keep track of over 100 shipments at once. According to James P. Martin of Sandia, field tests indicate that the system will also reduce the number of times the driver fails to contact the control center on the first try to about four per cent.

A number of safeguards experts would like to see the control center in constant touch with each shipment through an automatic broadcast of each truck's position and status relayed by satellite. Such a system can be built, says Mr. Martin.

Satellite communications have the added potential of an international network to monitor plutonium shipments worldwide — even aboard ship. Although there are many political obstacles to such a network, there is at least one inducement: the vital importance to all nuclear nations of guarding fissionable materials.

Making the Terrorist's Life Difficult

Because only a few kilograms of plutonium or highly-enriched uranium are sufficient for a crude atomic bomb, they are easily transported clandestinely. Material stolen in one place can be detonated on the other side of the globe. In terms of potential damage, the highly-centralized industrial nations are the most vulnerable. A crude bomb set off in the World Trade Center would probably kill 100,000 people, Dr. Taylor has calculated. But the social effects of nuclear terrorism will be global. No nation is secure.

Safeguarding fixed sites where plutonium is kept, such as fuel fabrication or reprocessing plants, is easier than guarding shipments. Doorway and room monitors exist that can detect down to half a gram of plutonium. Bank-type vaults or massive storage tanks can be constructed for fissionable material. Various surveillance and barrier systems can be installed.

In addition to physical security measures, there are other ways to obstruct a terrorist's activities. One widely discussed method is to "spike" plutonium with a highly radioactive material, and so make it deadly to handle. This course has been proposed by so eminent a supporter of nuclear energy as Nobel laureate Hans Bethe. To fabricate a bomb from "spiked" plutonium, one would need elaborate remote processing equipment.

Unfortunately, work done by Dr. Taylor, an industry investigation sponsored by the Atomic Industrial Forum, and a study done for the Nuclear Regulatory Commission (not yet released) all conclude that there is no perfect spiking agent. Some candidates would force a major overhaul of fuel cycle processing steps. Other radionuclides are not available in large enough quantities. Inducing radioactivity in the plutonium itself does not appear to be technically feasible.

The industry has suggested yet another dodge: before shipping the plutonium from the fuel reprocessing plant, dilute it with low-enriched uranium. Both uranium and plutonium are separated at the plant from highly radioactive spent fuel. A mixed blend containing 20 per cent plutonium oxide would be substantially more difficult for terrorists to use than straight plutonium. Further, such a safeguard would not require major alterations in techniques developed for mixing plutonium back into new reactor fuel.

Alarming Response

After discussions with several safeguards experts, the conclusion is inescapable that hardware exists or can be easily developed to make stealing nuclear materials more difficult than it is today. The hard problems lie in the institutions surrounding any safeguard system.

In 1972, the General Accounting Office of Congress investigated security at a number of commercial nuclear facilities. At one plant, a security guard called the local police every hour to assure them that all was well. A test of this arrangement produced a disquieting reaction. When the hourly call failed to come in, a squad car was promptly dispatched but went to the wrong plant, 14 miles away.

The vagaries of human nature, the difficulty that local law enforcers would encounter in dealing with armed terrorists, and the industries' reluctance to arm their guards have sparked proposals to establish a national police force charged with guarding nuclear materials. Such a force is viewed with alarm by some people who fear an embryonic Gestapo.

An alternative is industrial liaison with the military. Facilities having large inventories of plutonium could be located near military bases, with soldiers at the ready in case of a theft. Current procedure requires the governor to formally request military assistance from the President, who must agree. Perhaps channels may be opened to speed the procedure, but such a course might be politically impractical.

Methods for responding to a terrorist attack are perhaps most cogently organized within the general theory of a "widening circle of response." Fences, double-locked doors, vaults, and foam delay attackers as long as possible. Alarms instantly alert forces outside the plant. First to arrive at the scene are the local police, who attempt to interfere with the terrorists' activities as much as possible. State police soon reinforce them. Failing these measures, the military or some other special force are called in. Response continues to escalate until the criminals are captured.

Once such a system is established, it will be possible to counter almost any size terrorist group — at least theoretically. Only one problem will remain: how to keep the system working smoothly for a century or so.

David F. Salisbury is Science Editor for the Christian Science Monitor *and a regular contributor to* Technology Review.

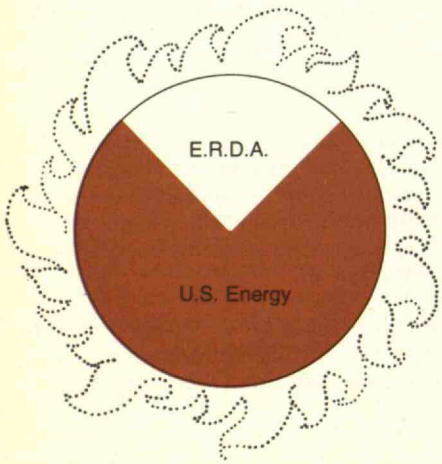
E.R.D.A. on Energy: A Plan Without a Policy

Washington Report
by
Colin Norman

When the O.P.E.C. countries cut off oil supplies to the United States two years ago, the reaction in Washington was nothing if not predictable. The besieged Mr. Nixon, after astounding some of his advisers by announcing that American technology would ensure energy independence by 1980, launched a series of presidential statements and bureaucratic changes designed to suggest that he had everything under control. Ten billion dollars spent over five years on an Apollo-style effort, and all would be well.

The political discussions and verbal histrionics which have been going on ever since have been no less predictable. Brickbats have been flying from one end of Pennsylvania Avenue to the other, enough reports and analyses have issued from federal agencies to fuel a few furnaces, and Congress and the White House have argued for two years over whether to decontrol oil and gas prices. In the meantime, oil imports continue to rise, and the nation is more vulnerable to an oil embargo now than it was in October, 1973.

In the midst of this utter confusion and political hyperbole, a few promising developments have taken place. Perhaps the most important is the amalgamation nearly a year ago of the hodgepodge of federal energy research and development projects into the Energy Research and Development Administration (E.R.D.A.). Here at last was the basis for a coherent national policy on energy research and development.



But according to a critique compiled by the Office of Technology Assessment (O.T.A.), E.R.D.A. has not gotten off to a very auspicious start. In a report prepared for three Congressional committees, O.T.A. — like E.R.D.A., a fledgling institution intent on proving itself — has raised some criticisms of E.R.D.A.'s plans and policies which cut deep into the philosophy of the federal government's approach to achieving energy self-sufficiency.

Stinging Criticisms

The target of O.T.A.'s criticisms is a plan published by E.R.D.A. last summer which sets out the agency's goals, and a second volume which details the programs through which E.R.D.A. hopes to achieve those goals. The plan will be updated every year and republished along with the President's budget requests; it will form the basis of E.R.D.A.'s operations.

O.T.A.'s analysis was performed by six panels of experts drawn from universities, industry, and nonprofit institutions, and coordinated by a high-level O.T.A. staff unit. The study should help to establish O.T.A.'s reputation, which has been somewhat tarnished by criticisms that it was slow to get off the mark and that it has not made much impression in Washington. In E.R.D.A.'s defense, however, it should be said that the plan was published less than six months after the agency was established, during which time E.R.D.A. was setting up shop and recruiting staff. Indeed, it is no small achievement that the plan was produced at all, and E.R.D.A. inevitably had little chance to make radical changes in the scope and direction of the programs it inherited. Nevertheless, O.T.A. is stinging in its criticisms, and its thorough analysis merits close attention.

Increasing Energy Dependence

Although O.T.A. acknowledges that the plan itself is a "significant milestone in the evolution of a long-term national policy," it finds the programs E.R.D.A. supports do "not appear adequate to achieve the stated goals." In fact, the deficiencies, unless remedied, "could impede the solution of short-term and mid-term energy problems by the United States, which could lead to an increased dependence on foreign energy sources," O.T.A. asserts.

The reason why E.R.D.A.'s approach may fail, and in fact prove counterproductive, according to O.T.A., is first that the agency perceives its role too narrowly, and second, that it has failed to pay sufficient attention to conservation. In short, O.T.A. faults E.R.D.A. for launching a N.A.S.A.-style effort when a much broader approach is needed, suggesting that E.R.D.A.'s "narrow, hardware-oriented approach . . . is designed to develop technologies rather than to explore solutions to national energy problems."

E.R.D.A. flatly states in its plan that its goal is to support technologies likely to increase domestic energy supplies, to open new choices, and to ensure some flexibility in future energy systems. Implicit in its approach is the idea that E.R.D.A. will produce technology, but that other energy policy matters are beyond its purview.

As a consequence, O.T.A. asserts, "E.R.D.A.'s narrow approach to the national energy policy goals might well fulfill a mission — developing new technology — without providing an answer — a secure energy future. Unresolved 'non-technical' issues — from inadequate incentives for commercialization, through environmental demands and competitive use of resources, to community resistance — could block the most sophisticated engineering achievement."

Too Many Cooks

In a sense, therefore, O.T.A. is accusing E.R.D.A. of tackling the intellectually exciting problems of technological development, while neglecting development of more mundane technology and leaving the more difficult political problems aside. The question thus arises: who is, or should be, tackling such problems?

Nominally, the Energy Resources Council, a top-level policy committee established by President Ford in his early days in the White House, is responsible

(Continued on p. 66)

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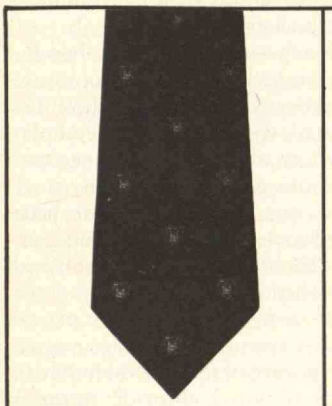

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Balancing the Costs of Cancer

Technology/Environment
by
Ian C. T. Nisbet

Regulation of cancer-causing pesticides has been simple in one sense. Effective alternative chemicals were available for all the major uses of the pesticides called into question, making it possible to eliminate them without loss of major benefits. The only substantial loss was a small cost differential between the carcinogenic chemicals and their substitutes. For example, the principal economic effect of DDT's cancellation was a small increase in the price of cotton — recently estimated as an average net cost of about two cents per person a year. In this classic example, cotton farmers accepted some of their own environmental costs. The process is, of course, highly painful to the manufacturers and distributors of the banned products, but their loss is more than offset by the gains accruing to the manufacturers and distributors of substitute products.

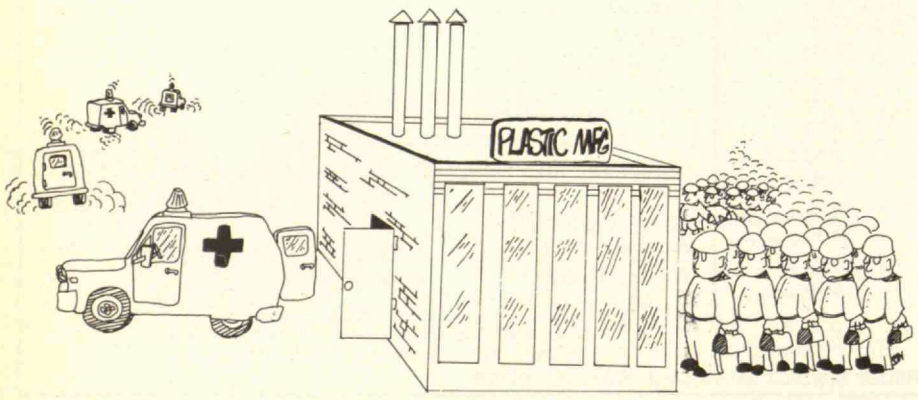
The situation is very different, however, when we identify a cancer-causing substance that provides major social benefits, and for which there is no feasible substitute. We have faced this dilemma for years in the case of asbestos, which causes lung cancer in occupationally-exposed workers. Asbestos is widespread in our environment. Its fibers appear in the air, in drinking water, in food, in beverages, and in human tissues. Yet asbestos has unique value as an insulating material. Even if we imposed stringent restrictions on its uses and release, its use in the past would ensure its presence in the environment as old products are scrapped and old buildings demolished. We should also weigh these questions in the case of plutonium, perhaps the most potent known carcinogen, capable of causing cancer in man in microgram doses. As our society becomes dependent on plutonium as a source of power, we must consider the virtual inevitability that significant quantities will be released into the environment, either by accident or design.

A Risk of Life or Prosperity

The issues have been posed most clearly by the case of vinyl chloride. Vinyl chloride, the raw material for polyvinyl chloride (PVC) plastics, has expanded in importance until its manufacture and use account, by one estimate, for about one per cent of the G.N.P. Now that it is almost too late to relinquish our dependence, we learn that vinyl chloride is hazardous: it is linked unequivocally to a rare form of liver cancer in exposed workers.

Vinyl chloride is widespread in the environment. Prior to the discovery of its hazards, an estimated 100 million pounds a year were lost to the environment during manufacture (two per cent of the U.S. output of 5 billion pounds) and a further 40 to 50 million pounds were released through deliberate dispersive uses. Although the most hazardous of these dispersive uses — as a propellant in aerosol spray cans — was banned in 1974, and although attempts are being made to reduce manufacturing losses, human exposure continues. Vinyl chloride is widespread in air and water at levels measurable in parts per trillion or parts per billion. Perhaps the most serious problem is that trace quantities of unpolymerized vinyl chloride are found in PVC and gradually escape, both into the air and into products (including food and other consumer goods such as cosmetics) sold in PVC packaging.

Although exposure of the general population is much less intense than exposure of the workers whose cancers gave the warning signal, we should not be complacent. We know already that nonoccupational exposure can be hazardous, since cases of the rare liver cancer have been reported in people living near manufacturing plants. One of the few well established facts about chemical carcinogenesis is the inverse relationship between latent period and rate of exposure to a carcinogen. Hence, if exposure of the general public to micrograms of vinyl chloride initiates cancers, these will not show up within the ten years required to demonstrate effects in workers. Without knowing the exact relationship between time and amount of exposure, we cannot predict whether to expect effects in 30 or in 300 years. There is no scientific method to assess quantitatively the risk to the general population, short of waiting for a lifetime and measuring the effect, as we have done with cigarette smoking.



Acceptable Exposure?

Faced with a situation in which a major technology is built upon a chemical that proves to be a cancer hazard, society has few options. Even if we had the power to do so, it would not be clearly beneficial to ban or phase out the use of PVC plastics: they would be replaced by other materials which may pose equal or greater hazards. Already, we suspect that at least one other monomer used in plastic manufacture is a carcinogen. Nor would it necessarily

make sense to end the "Plastic Age" and revert to using traditional materials: wood, leather, and glass pose their own hazards, both to the artisan and to the consumer.

Unfortunately, the course we have chosen is not much more rational. We are seeking by regulation to set "acceptable" standards for exposure to vinyl chloride without any objective means to determine the magnitude of the risks. How, then, can we intelligently weigh the benefits? We are seeking to minimize risks by controlling effluents, limiting occupational exposures, and restricting uses of PVC which lead to major human exposures (such as food packaging). All these measures impose costs on the manufacturers — another example of internalization of costs. However, the costs are very small compared to the *potential* risks: they fall far short of the damage that might be imposed on society if the "worst-case" estimates of risk prove correct.

A Dangerous Double Standard

By choosing continued exposure to the hazardous product at levels judged "acceptable," we imply at least two social judgments. However stringent the precautions to minimize exposure, workers in the industry will continue to be exposed to much higher doses of vinyl chloride than the general population. Although federal law requires strict regulation of occupational exposure to carcinogens, the standards set by the Occupational Safety and Health Administration for asbestos, for example, are not encouraging. Indeed, the proposed standard for vinyl chloride offers little or no assurance of safety. Whether one accepts speculations that regulated use of vinyl chloride will pose a negligible hazard to the general public, there is certainly no promise of safety for the workers. The moral implications of this double safety standard deserve some thought.

Of course, it can be argued that all occupations pose dangers, and that many workers in the chemical industry are aware of and accept the risk of cancer as one of many occupational hazards. It can be argued further that cancer is not clearly worse than some other occupationally-induced diseases, such as "black lung." In comparison with other occupational hazards, chemical carcinogenesis has attracted unusually stringent regulations. But this does not necessarily mean that carcinogens are over-regulated: rather, we must conclude that other occupational hazards are under-regulated. Perhaps other industries should be paying their full costs.

Ian C. T. Nisbet, who writes regularly for Technology Review, *is Associate Director of the Scientific Staff of Massachusetts Audubon Society; he is a graduate of Cambridge University, England, in physics (Ph.D. 1958).*

Keeping Engineering within Budget

Special Report
by
Myron Kayton

Everyone knows that today's high technology, such as spacecraft and electronic systems, is subject to cost overruns. We are often dismayed to find our funds at an end before our project is completed. The public blames the cost overrun on anything from incompetence to the venality of the "military-industrial complex," and remembers with nostalgia a mythical past when budgets were perfectly predictable.

Yet a look at an earlier era of burgeoning technology — the civil engineering boom of the 19th century — suggests that cost overruns may be endemic to technological innovation. The engineers of that century provided the western world with clean drinking water, sewage disposal, and the machinery that replaced so much manual labor. They made farmers of peasants by providing inexpensive transportation to urban markets.

How much did these civil engineering works cost, and how accurately were their costs predicted? A look at a few representative projects should demonstrate that the pioneers in new technology had the same problems as their 20th century successors.

New Technology at a Price

Sometimes an economical solution to a problem requires the invention of new technology. The Hoosac Tunnel, near North Adams, Mass., is a case in point. Loammi Baldwin, an American engineer, conducted the first surveys in 1825 and estimated the cost of the railroad tunnel, nearly five miles long, at $370,000. Work started in 1850, but the builders encountered a discouraging series of technical obstacles — primarily hard rock and flooding. The tunnel was re-estimated in 1854 at $2 million and again in 1858 at $3.9 million. Only in 1874, after the introduction of the compressed-air drill, nitroglycerin, and state aid, was the Hoosac Tunnel finished, at a total cost of $10 million. In the meantime, its construction greatly benefited all subsequent tunnels throughout the world, though largely at the expense of the Commonwealth of Massachusetts which in 1884 was still spending half its budget to pay off the bonds.

Other examples of 19th century engineers' inability to estimate the cost of new technology are the tunnels that were bored through the Alps to connect the rail and highway networks of France and Switzerland with those of Italy. The tunnels were constructed 3,000 to 4,000 ft. above sea level, high enough so the length need not exceed 12 miles, yet low enough so heavy snow need not be cleared from the approaches in winter. Each tunnel typically employed 4,000 men for 20 years, digging without benefit of intermediate vertical shafts. Workers' villages had to be built and hydropower plants constructed at the portals to supply compressed air and, later, electricity to power machinery. The engineers had to deal with flooding, rock slides, and unexpectedly high subterranean temperatures. As a result of these unforeseen problems, all the tunnels were beset by bankruptcies and schedule slips. The first tunnel built, the Fréjus-Mt. Cénis (opened 1871), overran by 130 per cent. As the technology of geological prediction, blasting, and removing loose rock improved, the overruns fell steadily thereafter to 54 per cent on the St. Gotthard Tunnel (1882) and 13 per cent on the Simplon Tunnel (1906).

The Eads Bridge spanning the Mississippi River at St. Louis is another example of price inflation associated with new technology. Construction started in 1868 on a bridge to be built of three arches, each spanning 500 ft.; it was to be the first bridge in the world to use steel. Caisson technology (necessary to build piers in the deep water of the river) barely existed. Many problems had to be solved, such as designing a sand pump to remove excavated material, means of lighting the caissons without the risk of fire and asphyxiating smoke, and means of avoiding the "bends" (which first afflicted the workers on this bridge). The contract to erect the steelwork called for completion in 44 days, but the steelwork was completed only after the bridge company extended the date one year. There were many changes in steel suppliers and fabricators in an attempt to procure steel bars of acceptable quality. The Eads Bridge opened in 1874, at a cost ten times the $600,000 first estimated 35 years earlier. It is still in use as a major railroad and highway bridge.

Up, Up, and Away

Inflation was, and continues to be, a chronic source of financial woe. The longer a project takes to finish, the more unpredictably does its cost rise due to inflation. Thus, at least part of the 12,000 per cent overrun on the Erie Canal, constructed during a 43-year period, must be due to the inflation associated with the War of 1812. The Caledonian Canal, begun in northern Scotland in 1802, overran 170 per cent in the 20 years it took to build, and the overrun would have been larger had the depth of the canal not been reduced by one-third. Part of the overrun must have been caused by the inflation of the Napoleonic Wars.

There are other equally dramatic examples. One, the Cincinnati-Covington Bridge across the Ohio River, was the longest suspension bridge in the world when it opened in 1867. The first estimate — $150,000 — was made in 1845. Eleven years later the company formed to build the bridge proposed that it would take three to four years at a cost of $700,000, of which only $365,000 was raised. Work stopped in 1857 when funds were exhausted. Three years later, the total cost of completion was again projected, this time at $1 million. The bridge was finally finished at a cost of $1.2 million. Although its engineers had faced few new technical problems, they had been forced to ride out the financial panic of 1857 and the Civil War.

Politics and Feathering the Nest

History suggests that inexperience, political corruption, and mismanagement are obstacles to accurate cost estimation, though it is difficult for today's observer to discern mismanagement in the dusty histories of most projects. The Erie Canal, for example, was first budgeted by local surveyors having no knowledge of the sophisticated canal-building techniques and experience of their European predecessors. The low estimates were appar-

Cost overruns were as much a headache to the engineers of the 19th century as they are to engineers today. And unexpected requirements for new technology, then as now, are a common source of fiscal frustration. For instance, the Hoosac Tunnel (*right*) was begun in 1825 and might never have been completed — in 1874 — were it not for the invention of the compressed-air drill and nitroglycerin. Originally estimated at $370,000, its final price tag was $10 million. (Engraving courtesy of *the* Bettmann Archive)

ently also fostered by politicians who wanted to begin construction quickly and open western New York to commerce. Political mischief had a hand in building the Brooklyn Bridge, as well. Estimated in 1868 to cost $7 million, the bridge opened in 1883 at a total cost of $13 million, some of which enriched the coffers of members of the Board of Trustees who awarded materials contracts to their own companies. Another well-publicized case is the abortive digging of the Panama Canal by the French from 1880 to 1889. Its promoter, de Lesseps, was sentenced to prison for fraud as a result of tripled costs and charges of bribery.

One present-day cause of overruns not often found in these early projects is the addition of new requirements after an estimate has been made. Defense contracts used to be the best example. One of the newest examples is the necessity for a builder of a nuclear power plant to abide by government safety regulations adopted after a contract has been signed between a utility company and a manufacturer, leaving the buyer and seller to debate one another's responsibility for the unforeseen costs.

Who Pays?

The cost of building a motor similar to thousands built in the past can be readily estimated. There are many competitive buyers and sellers, and the marketplace sets a selling price for the motor. But when we buy a one-of-a-kind item before it is built, selective shopping is impossible. The cost must be calculated either on the basis of past experience or by estimating the labor and materials for each activity required on the way to completion.

Faced with technological unknowns, no accountant can create certainty. Encountering unexpected quicksand inside a mountain must delay a tunnel and cost money. Imprecision is certain when the product contains new technology or when construction takes so long that we are exposed to inflation in our own costs and in those of our suppliers. Even in the world of handbook engineering, cost overruns still occur; the 1965 Mt. Blanc tunnel was completed at a cost of 60 per cent over the contracted estimate, and the 1973 Eisenhower tunnel in Colorado cost 100 per cent over the contracted estimate.

We can conclude that cost overruns, always with us, are likely to remain troublesome on large and innovative projects. We must then consider the question, "Who should pay?" The businessman's response can take either of two extreme forms:

— The fixed-price contract, in which the contractor assumes the entire risk and is bankrupted if the uncertainty materializes.

— The cost-plus contract, in which the buyer assumes the risk.

For the typical early projects we have summarized, the buyers used a fixed-price contract that placed the full burden of risks on the contractor, with no care for improving technology or for assuring the contractor's solvency. Thus it is no surprise that bankruptcies plagued the early construction of canals, bridges, and tunnels.

After World War II, when rapid technological advances were asked of the American aerospace industry, cost-plus contracts were first widely used. Competition was based on the quality of design and the probable ability of management to control future costs. The buyer assumed all the risk and took title to newly developed technology which he disseminated throughout the industry (producing a "knowledge explosion"). Unfortunately, once the contract was awarded, the recipient sometimes had little incentive to keep costs down.

If the buyer selects a fixed-price contract in the face of uncertainty, he may be paying for the largest risk his bidders can imagine. On the other hand, he may be saddled with a defaulting or poorly performing low bidder. The buyer's alternative, when he cannot himself estimate the size of a reasonable bid, is to assume part or all of the risk himself, using a cost-plus contract.

Neither alternative is very satisfactory. Instead, I suggest that we seek arrangements whereby the financial risk of a project is allocated among the parties that stand to benefit from its success. Where a new technology is sold only to the government (for example, for defense) or where it augments the nation's competitive position abroad, the taxpayer should accept the risk. Where a private company is likely to be the principal beneficiary, it should accept the risk. Implementation of this suggestion requires administrative machinery to determine the beneficiaries, but it is clearly the policy direction being followed today in the United States and western Europe.

Myron Kayton, whose Ph.D. in aeronautics and astronautics (instrumentation) is from M.I.T. (1960), is a Senior Staff Engineer to the Manager of System Engineering Operations at TRW Systems, Inc.

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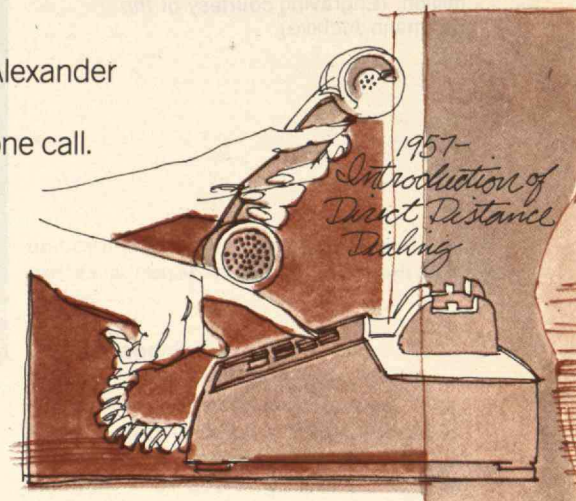

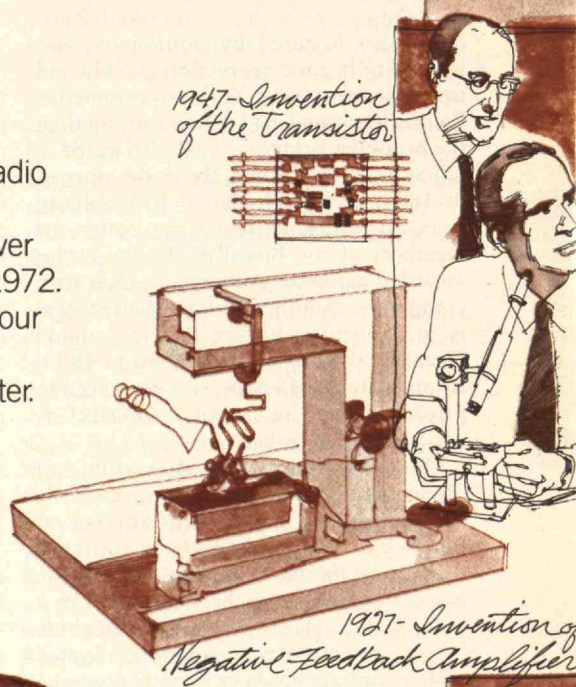

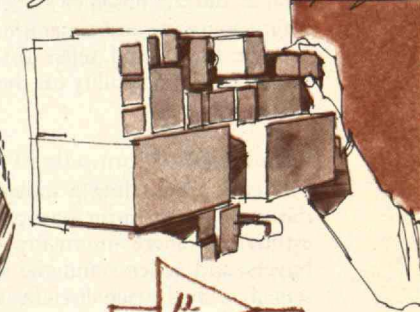

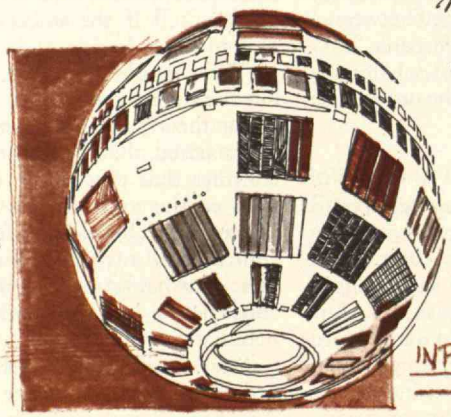

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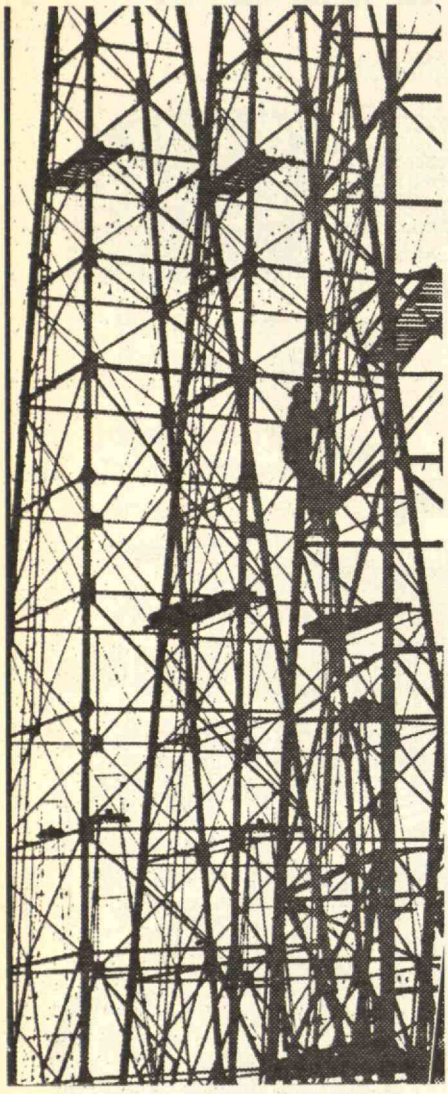
Book Reviews



New York Times

Rigs at Sea

Energy Under the Oceans: A Technology Assessment of Outer Continental Shelf Oil and Gas Operations
D. E. Kash, I. L. White, K. H. Bergey, M. A. Chartock, M. D. Devine, R. L. Leonard, S. N. Salomon, H. W. Young
Norman, Okla.: University of Oklahoma Press, 1973, xxii + 378 pp., $4.50 paper

North Sea Oil and Gas: Implications for Future United States Development
I. L. White, D. E. Kash, M. A. Chartock, M. D. Levine, R. L. Leonard
Norman, Okla.: University of Oklahoma Press, 1973, xiii + 176 pp., $2.95 paper

Reviewed by J. Paul Walsh

Late this spring, the *New York Times* quoted Rep. Al Ullman (D.-Ore.) as saying that the United States is sliding quietly into an "invisible crisis," noting a 35 per cent increase in oil imports during the first three months of this year — a winter of mild weather and deep business recession. A little later, the Shah of Iran warned that oil prices would rise in the autumn. And at the same time, President Ford said, "Our American economy runs on energy. No energy, no jobs. In the long run it is just that simple." To further complicate this picture, domestic oil production has been decreasing for the past three years.

These books were written before the Arab states embargoed oil shipments to the U.S. and before gasoline prices at the pump rose to about 60 cents a gallon. But this does not detract from the books' value; in fact, the existence of this major threat to our energy security enhances their importance. The relative weights of the books' conclusions might be changed now, but not their major thrusts.

A Cultural Frame for Technical Problems

Energy Under the Oceans is multidisciplinary. It assesses all the factors — technical, economic, political, and social — that must be considered if undersea resources are to be developed in the best possible way.

The study's major conclusions, as I see them, are that development of oil and gas resources is too important and affects too many people to be left to the oil companies; the important problems are managerial, not technical.

Technology assessment is a useful tool. It offers a systematic method for predicting the consequences of a course of action, or more specifically, of a change in a system. Studies such as this attempt to expand the focus beyond purely technical and economic considerations to regard cultural impacts. Thus, it is argued, the decisionmaker can now say with confidence, "If I do this, such and such will happen." So far so good. Having completed that exercise, the authors present a plan for development. And here, in my opinion, is a great difficulty. An analysis of this sort can only answer the question, "What is likely to happen if I do this?" It cannot answer the question, "Is this course of action good or bad?"

Those of us with technical problem-solving experience often mistakenly believe that the techniques that have been successful in managing a technical project will be equally successful in managing development of a resource. In fact, it was probably easier to put a man on the moon than it is to manage New York City. And if that's so, it is because the objective — the moon — was known and agreed upon. A proposed course of action could be examined against the single criterion, "Does this improve the probability of putting a man on the moon?" Try that for New York City or, more pertinent here, try it for the development of the U.S. outer continental shelf oil and gas.

Braving the Elements

How these problems are being addressed by the countries that have found oil and gas in the North Sea is the subject of the second book.

North Sea Oil and Gas was produced in a short time and is based on published reports and interviews conducted in Europe during July and August, 1973. Although one feels it was assembled hastily, it is a sound introduction to new questions that have been raised, their comparison with U.S. experience, and their solutions.

The North Sea is a hard place to work. The water is deep and cold. The weather is terrible. Design criteria for platforms in the British Petroleum Forties field include wind velocities of up to 130 m.p.h. and waves of 94 feet. It is so bad that in some months, work is possible on only a few days! So far weather forecasting has been poor. It is claimed, for example, that if the forecast is for reduced wave heights in two days there is a 50 per cent chance that the heights will increase. Thirty-five per cent of the time, the waves are higher than eight feet. Currents and water turbidity are high, making underwater work extremely difficult. The British Forties field is 110 miles out and the Ekofisk is 185 miles out.

The technology used in the Gulf of Mexico evolved over many years, while the technology used in the North Sea was both adapted from that used in the Gulf and designed and developed on the spot to meet new conditions. While much of the equipment is simply bigger and stronger than in the Gulf, that design approach doesn't always work now, and will not work much longer as the operation moves to deeper water.

Many innovative, courageous solutions to these new problems have been devised. One example is the 1 million barrel concrete oil-storage tank installed by Phillips in 1973 in 230 feet of water in the Ekofisk field.

Petroleum and Political Games

These new conditions push the engineer to the limits of his knowledge. Just two examples:

— How fast do the small cracks — inevitable in these large, complex, welded structures — grow under the random loading of the waves in the corrosive environment of the sea?

— How does the sea floor respond over long periods of time to the loads from these enormous structures as they in turn are pounded by the sea?

Neither question can yet be answered.

The governments involved in North Sea oil and gas development are important players and each one sees its role differ-

ently. Their equity positions are delicately designed to maximize the take while enticing the oil companies to accept the risks involved. The British government, for example, is doing everything possible to bring oil ashore at the earliest date while the Norwegian government is slowing development so as to neither deplete the resource nor overheat the economy.

Through independent classification societies (Lloyd's Register of Shipping and Det Norske Veritas are the two leading ones), the governments exercise detailed design approval of all aspects of the venture. For example, just before the Ekofisk tank was to be towed to the production site, the Norwegian government asked, "Is the tank bottom strong enough to withstand the unevenness and roughness of the sea floor at the proposed site?" Deployment was delayed until that question was answered.

The governments contribute heavily to the support of research and development needed to advance the required technologies. In Great Britain, the Secretary of State for Energy has a Board composed of members from industry and government which advises on research and development programs designed to "ensure the safety, and efficiency of offshore operations and . . . [*to improve*] *the competitive position of British industry in the offshore field.*" (Emphasis the authors'.)

Exploration for North Sea oil is an exciting technical, economic, and political game. The stakes are high (Great Britain has without doubt mortgaged her future on the outcome.) The United States can learn much from this game, and these two books are a good introduction.

J. Paul Walsh is Superintendent of the Ocean Technology Division of the U.S. Naval Research Laboratory. He is currently on assignment to the Office of Naval Research in London.

The Hazards of Teamwork

Organizing the Transnational: The Experience with Transnational Enterprise in Advanced Technology
Milton S. Hocmuth
Leiden: A. W. Sijthoff, 1974; xiv + 211 pp.

European Technology: The Politics of Collaboration
Roger Williams
New York: John Wiley and Sons, 1973; x + 214 pp., $13

Reviewed by Christopher Harlow

In a year in which the Anglo-French supersonic transport "Concorde" has come close to being accepted by the F.A.A., and when its American competitor is buried with the epitaph, "Too Expensive," it is time to think about the heavy cost of technical change in a society which has not previously felt the pinch. Will America, like European countries, turn to technological partnerships abroad in order to finance the development of new products and processes now straining her resources? The European experience suggests that she should not; the headaches are many and the financial advantage unproven.

The most compelling argument in favor of transnational programs in advanced technology is that they should conserve scarce research and development funds and manpower. Where a number of countries have similar objectives, combining their budgets should produce more knowledge or new technology for the same expenditure, or the same amount for less money.

Knowledge and technical discoveries are indeed hard to quantify. Nevertheless, the resource-saving argument has inevitable attractions, particularly to politicians and their economic advisers. When science and technology programs are put up for public support, it is part of the process of decision that some price tag be attached to them, though cost forecasting in advanced technology is as unreliable an art as weather forecasting in Boston. Once costs are estimated in the proposals for weapon development, for nuclear power systems, for space programs, and for aircraft projects, they lend an appearance of conformity to the rules of mathematics. If one fast breeder reactor would cost £400 million (Britain's estimated development budget to 1980), then half a fast breeder should cost £200 million in a two-country project and a quarter should cost £100 million in a four-country project.

Or, at least, so a number of prophets hoped, along with most of the European countries that entered some form of collaborative technological project or science program during the 1950s and 1960s. The commitments are not completely naïve. Even the enthusiasts admitted that there would be "collaboration costs" to swell total program estimates. (The head of British Aircraft Corp. estimated an increase of one-third in research and development costs; others predict it to be far greater.) And for those who were impervious to the mathematical approach, there was the "internationalist" argument that teaming one's resources with those of another country would bring untold diplomatic benefits.

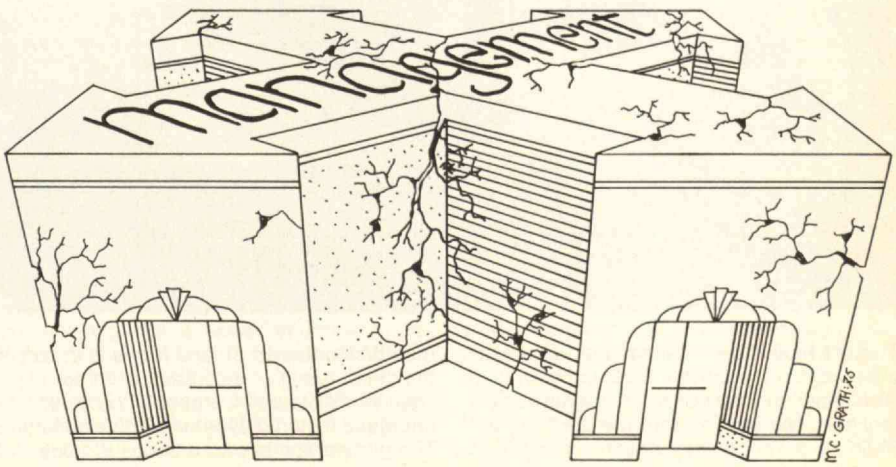
Juggling Conflicting Interests

Within these two rather simplistic extremes were motivations having a more practical appeal. *European Technology* summarizes the negotiations and aspirations of the major projects in aircraft, space, nuclear power, and computers. And *Organizing the Transnational* presents detailed case studies of the management of six programs: the N.A.T.O. Hawk missile, the European Space Launcher (ELDO) and satellite program (ESRO), the Main Battle Tank '70, Concorde, and the Franco-German communications satellite, Symphonie.

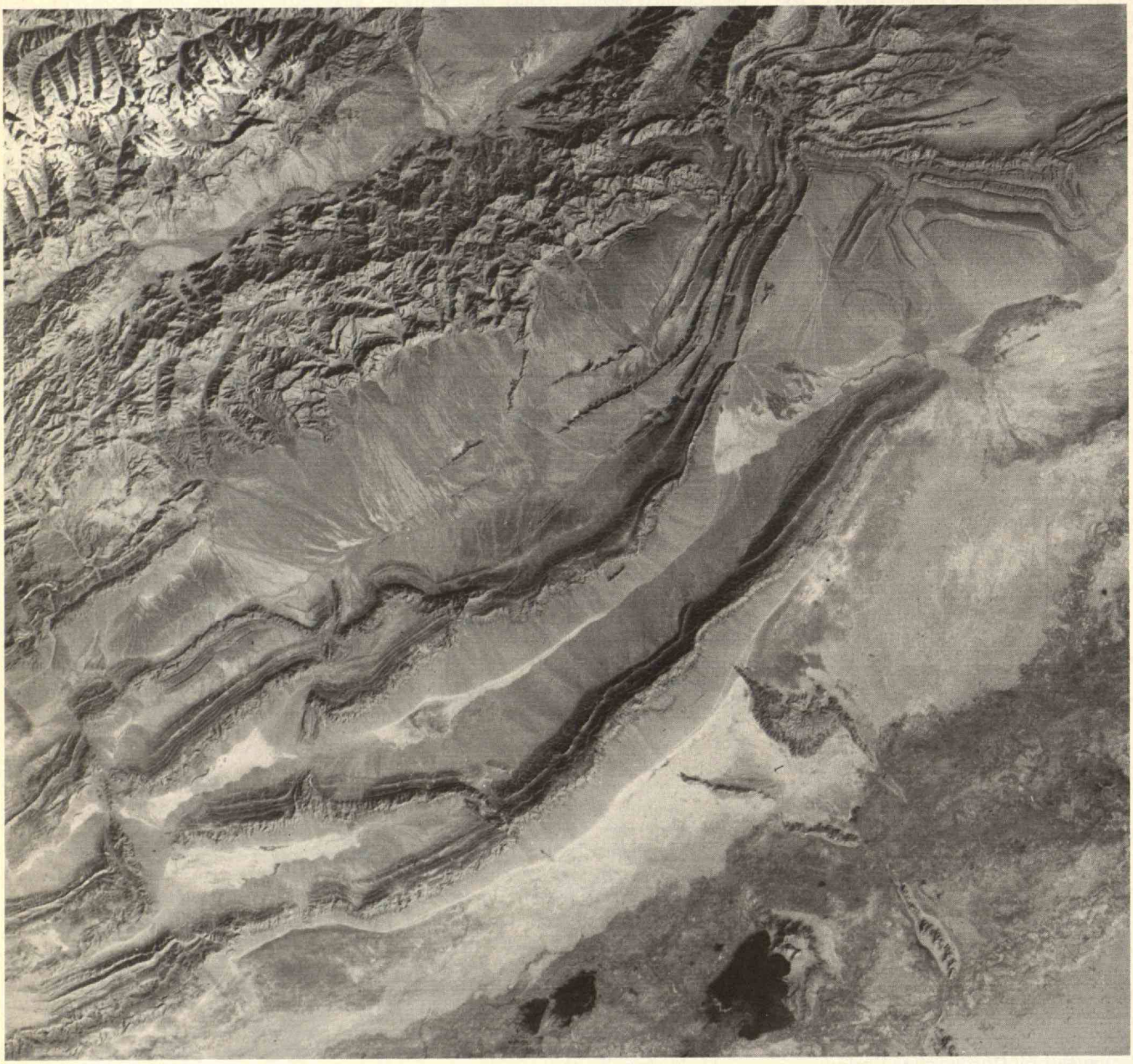
French participation in many projects was conditional upon special concessions. France was the dominant partner in the Hawk production program, and provided the prototypes for the Jaguar fighter and the abortive Anglo-French variable-geometry aircraft. In three aircraft and space projects, Germany was inclined to invest more resources than she received in production. Having lost ten years of aircraft development after World War II, the Germans saw collaboration as a means to speed technology transfer. Britain during the early 1960s faced a lopsided competition with the U.S. in advanced technology industries. She was very much afraid that American dominance had already been established in aircraft, nuclear power, computers, space, and electronics, and embraced collaboration as a route to a European market comparable to the U.S. domestic market.

These three motives — the desire to economize, the goal of a federal Europe,

(Continued on p. 67)



Trend of Affairs



Twisted fault lines and zones of volcanism characterize the earth's crust in central Asia. Now an analysis of photographs (such as that above) from the Earth Resources Technology Satellite reveals that this confusion of land forms is in fact the direct result of a collision of three continental plates — probably the most energetic tectonic event in earth's history. The photograph shows a series of folds and thrusts at the southern edge of Tien Shan, between Sinkiang (China) and Kazakhstan (U.S.S.R.).

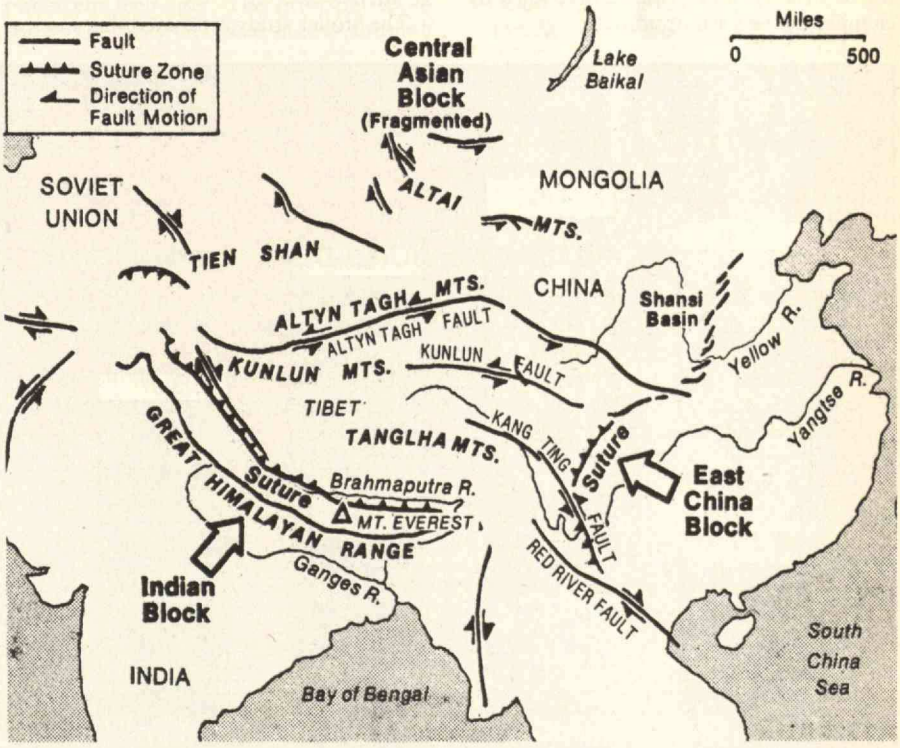
Trends This Month

GEOPHYSICS

Plates in Collision

The modern theory of plate tectonics assumes the surfaces of the continents to be like rigid plates of rock driven like lakes of ice across the surface of a mushy, fluid sea. One of two things must happen when two such plates, driven by immense geophysical forces not yet totally understood, collide: one plate may slide down under the other, creating an area of doubly thick crust; or one must push the other out of the way.

Either case results in fault lines, characterized by frequent earthquakes, and crustal deformations, from which rise mountain ranges. The old, worn-down Appalachian Mountains are proposed to be the result of a plate collision which fused long ago. Two geologists studying earth satellite photographs at M.I.T. proposed during the summer that a series of such collisions is responsible for most of the outstanding geological features of southeastern Asia, including the Himalayas and the zones of severe earthquakes spreading north of the Himalayas in China, the Soviet Union, and Mongolia. A delegation of Chinese geologists visiting M.I.T. last fall confirmed this



Asia is made of three continental blocks whose powerful collision some 40 million years ago threw the Himalayas up to their present heights and caused patterns of fracturing throughout central China and Mongolia. Chinese geologists visiting the U.S. last fall said that their studies confirmed this map, drawn last year at M.I.T. by Peter Molnar and Paul Tapponnier after studying earth satellite photographs. Chinese expeditions have returned rocks from the summit of Mt. Everest which turned out to be limestone laid down 500 million years ago in shallow seas, and north of the Himalayas they have found 300-million-year-old-fossil plants typical of those known in India. (Map: Peter Molnar and Paul Tapponnier from the *New York Times*)

judgment and added details drawn from their own detailed studies of Chinese land forms.

Continental blocks representing Eurasia and India had been moving on a collision course since the late Cretaceous (60 to 70 million years ago), said Professor Peter Molnar and Paul Tapponnier in *Science* (August 8, pp. 419-25), with relative movement as much as 180 millimeters per year. The collision — and it was a prodigious one — came in the Eocene (40 million years ago), and the relative motion was reduced to about 50 millimeters a year. The event raised the Himalayas and opened fractures to produce areas of earthquake faults and volcanic activity across much of central and eastern Asia. China is still moving eastward at more than one inch per year.

Professor Molnar and Dr. Tapponnier think this new analysis, revealing more than heretofore known about the energies involved in the collision of continental plates, "must place an important constraint on . . . the driving mechanism of plate tectonics." — *J.M.*

ENERGY

A Nuclear New England . . . . Unavoidably Economical

No matter how you rejigger the figures or alter the assumptions, nuclear power has a clear economic edge over coal and oil for New England base-load electricity, according to a recent study by a consultant for New England Electric Co. Although New England was the focus of the study, the findings could shed some light on the economic coal-nuclear debate in other parts of the country.

Figures compiled by the S.M. Stoller Corp., a subsidiary of Arthur D. Little, Inc., gave nuclear power an economic edge over coal of about 10 to 15 mills per kilowatt hour generated, an advantage which persists even with pessimistic nuclear assumptions and optimistic coal assumptions. The economic advantage over oil is in this same range, also despite changes in the assumptions.

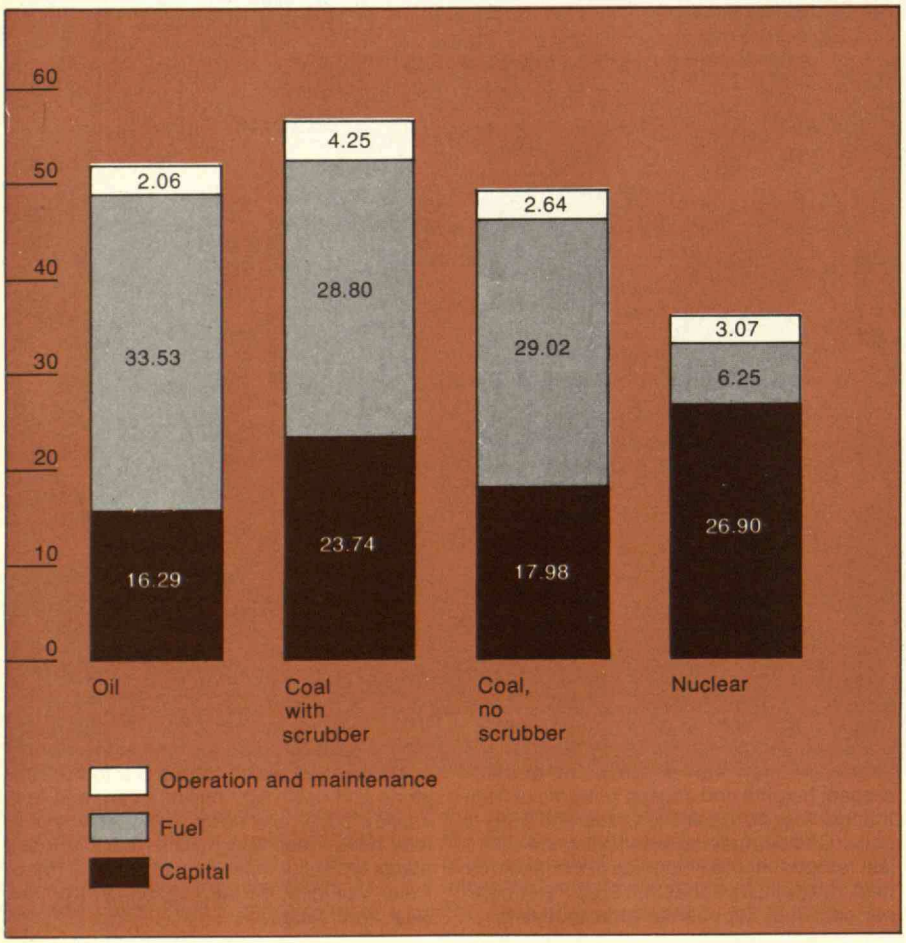
In a recent speech to a meeting of Boston power engineers, Robert J. McWhorter, S. M. Stoller vice president, outlined the study and brought the engineers up to date on developments which might affect the findings. The study was released early in 1975.

Among the study's assumptions were that the oil cartel would continue to drive oil prices up, to about $15 per barrel by 1990. Coal, whose price has leaped 400 per cent in the last 18 months, would continue to rise to about $60 per ton in 1990, from about $30 per ton today for eastern deep-mined coal. Finally, nuclear fuel would suffer shortages in the 1980s and prices would rise to about $155 per kilogram of heavy metal — that is, ready-to-go fuel.

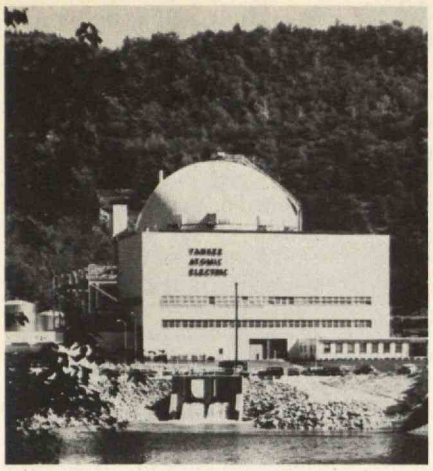
The Stoller study estimated that nuclear plants and coal plants with stack gas scrubbers would be up and running about the same percentage of time (70 per cent) as nuclear plants. Coal plants without scrubbers would be available about 75 per cent of the time.

Most of the argument over whether coal or nuclear would be cheaper centers around the capital costs of building the two kinds of plants. The Stoller study estimated that 2,400 megawatts of plant would cost about $863 per kilowatt for nuclear, $697 per kilowatt and $565 per kilowatt for coal with and without scrubbers, respectively, and $512 per kilowatt for oil.

After digesting all these figures, the analysts discovered inevitable cost advantage of nuclear power for New England. The score: nuclear, 36 mills-per-



Nuclear power comes out on top economically in New England regardless of how the components of power costs are varied. This breakdown of power costs was performed by the S.M. Stoller Corp.



Economics might make nuclear power plants such as this one a common sight in New England. (Photograph courtesy of the Atomic Industrial Forum.)

kilowatt-hour; oil, 52 mills; coal without scrubbers, 50 mills; and coal with scrubbers, 57 mills.

But the key to any good prediction is to know how well the results hold up when things don't exactly go your way. The Stoller Corp., in fact, did a lot of variations on their themes (*see graph*) and could find little economic hope for oil or coal in New England.

Support for the prediction also comes from another sector: to run coal plants, one needs a good supply of coal, which means a good railroad to bring it in. "For one utility to carry the weight of upgrading the Northeast railroads on its back would be impossible," said Mr. McWhorter. Thus, if one utility goes coal, all must go. Of oil, he said, "We feel very nervous recommending oil for a base-load plant because of the insecurity of supplies."

But there are also short-term supply problems with nuclear fuel, he pointed out, citing a Westinghouse announcement that it could not honor earlier commitments to supply nuclear fuel. These were seen to be problems of distribution, rather than real shortages, he said. A little lending of nuclear fuel from those utilities that have delayed nuclear plants to those who are short-fueled would help.

Other events since the study was completed have left Mr. McWhorter "feeling good" about the projections. Despite such items as inflation and the overwhelming concern over the disposal of nuclear wastes, the economic edge is still nuclear's.

Certainly coal plants would probably be more economical in the West, where strip-mining could bring huge supplies at about one-fourth the price of eastern coal. But this won't help the East, said Mr. McWhorter, because shipping western coal East would cost three times as much as shipping eastern coal, just about wiping out any price advantage. — *D.M.*

Limits-to-Growth '75: Long-Distance View of a Mad Hatter's Tea Party

Reading the speeches, papers, and journalistic reports from the Limits-To-Growth Conference in suburban Houston, Texas, lat fall was like observing a Mad Hatter's tea party, where the idiosyncracies of the guests far outshone the attractions of the tea and cakes.

The oddities began with the brochure announcing the conference. This is no limits-to-growth conference, thought this writer, for the magnificent brochure announcing it grew and grew and grew, unfolding into a two-by-three-foot poster splashed with the promise of intellectual ferment à-go-go. The price seemed just as limitless: a $325 registration fee, $265 for semi-impoverished government officials and academicians. And there was a matter of $42 per day for room and board, plus travel expenses.

The limits-to-growth conference was being held in one of the most limitless areas in the country — the lush, sprawling land near Houston, Texas, where neo-Roman, neo-colonial, neo-modern, and neo-neo housing developments and shopping centers spring up like acne on a pubescent teen-ager. The principal sponsor was no fusty technical society, but millionaire oil man George P. Mitchell. Among his potential gushers is the Woodlands, the "new town" in which the meeting was held. The Woodlands, besides attracting a wide diversity of settlers, hopes to attract a campus of the University of Houston — another partner sponsoring the conference.

Thus did the peculiarities surrounding the conference coalesce into a bewildering, quivering jello of circumstance.

Some of the conference sessions and luncheons were held on the tennis courts, and at these and other sessions two teams of conferees — the growthers and the limits-to-growthers — served stinging verbal volleys to one another. While some of the volleys were straight and true, others skidded unrealistically off the court. One suspects that the truth bounced about somewhere on center-court.

The spectators included not only the well-heeled businessmen and ever-so-slightly down at the heels academics, but also a number of reporters casting about for copy to justify the trip down to for-God's-sake-Texas.

Jay W. Forrester, M.I.T. professor,

The Price of Radiation Exposure

If the market system successfully sets our priorities on materials, can it do the same for pollution — even for that most subtle form of pollution which results from radioactivity?

It can, indeed, thinks Richard Wilson, Professor of Physics at Harvard. Professor Wilson notes the recent interim ruling of the Nuclear Regulatory Commission: in the absence of certain knowledge, N.R.C. asks the operators of nuclear reactors to reduce radiation exposure to the general public until the cost of further reduction exceeds $1,000 per man-rem (the product of population and radiation dose measured in rems, each rem being radiation equivalent to that from one roentgen from high-energy x-rays).

If the operator of a reactor fails to meet this requirement, N.R.C. orders the reactor shut down, and until corrections are made power must be generated by some other — perhaps more polluting in another realm — system. But Professor Wilson finds the $1,000 per man-rem requirement a "very conservative" one, and in a short paper in *Science* (October 31, 1975), he proposes that society would be better served by leveraging correction of the reactor than by substituting a more conventional, more polluting alternative.

Say $1,000 per man-rem as a fine, proposes Professor Wilson; such a charge "will usually cost less than shutting a power station down." And, if the National Academy of Sciences is correct in estimating that one man-rem might cause 10^{-4} cancers, the fine "corresponds to a charge of $10 million per cancer." An adequate incentive to any utility to mend its ways, thinks Dr. Wilson, and a convenient source of income for cancer research and treatment. — *J.M.*

made valid points when he advocated emphasizing *social* limits-to-growth rather than physical limits. His ace was that maybe technology can overcome some physical limits, but the social consequences are just as deadly. "Social limits (to growth) are already exerting growth pressure in the form of drug addiction, kidnappings, aircraft hijackings, sabotage, revolution and a returning threat to atomic war," he said.

Is Business Really Cyclical, and Why?

Economists identify a four-year cycle of growth and recession, a 20-year fluctuation in growth rates (the Kuznets cycle), a 45-to-60-year cycle in financial indicators (the Kondratieff cycle), and perhaps a 200-year systemic life cycle. Are they real? And why?

Consider the labor sector in Jay W. Forrester's new National Model. Preliminary runs made at M.I.T. late last summer, first reported last fall by Nathaniel J. Mass to a conference of alumni of the Sloan School of Management, suggest that there is in fact a four-year cycle: the demand for labor expands, creating a shortage which lures more people into the labor market; the result is a surplus — unemployment — which causes demands for economic expansion to provide more jobs; then the resulting expansion creates another shortage — all this repeating itself in about four years.

If several sectors are involved — production, financial, and labor, for example — the cyclical action is far more complex and takes longer. It might work like this, said Mr. Mass: a one-time increase in the order rate depletes inventories and produces a backlog of orders. The result is three pressures for expansion of production: to reduce the backlog, to replenish inventories, and to increase the level of inventories against future bulges in the order rate. There is a call for new capital equipment, which sets up a cyclical movement of its own in the financial sector; and there are also repercussions in the labor sector. When the future bulges fail to materialize, inventory is allowed to decline, investment and labor demand drop. Suddenly they have dropped too far, backlog builds, and the stage is set for the cycle to repeat.

The model suggests that all this, stemming from a single one-time increase in the order rate, may happen in a self-perpetuating cycle of surplus and scarcity that repeats itself perhaps in 20 years. — *J.M.*

"In the present energy shortage, the first question should not be 'Can technology provide unlimited energy?' Instead we should ask, 'If unlimited energy were available, should we want it?' "

Professor Forrester also called for a national focus on limit-to-growth strategies: "The debate on limits-to-growth has tended to focus on the world as a whole, major regions, and on issues outside any particular person's own country. Such a broad and external perspective implies that the problem belongs to somebody else. Furthermore, only nations have effective political processes. The external perspective sees difficulties as being imposed from the outside, and war against others as the solution."

Professor Forrester also advocated a keener awareness of the intermediate modes of behavior that lie between the short-term business cycle of only about five years, and the centuries-long cycle of growth.

"Historians treat the rise and fall of civilizations — the time span of growth, equilibrium and collapse. The business press, economics books and political debate all overemphasize the three-to-seven-year business cycle. But dynamic modes of behavior extending over ten to a hundred years receive less than their due attention."

Another limits-to-growther, Herman E. Daly, outlined a number of complicated schemes to help the cause along. He had the government setting up a system of quotas for scarce materials. Business would purchase a "right-to-buy" before going to the marketplace. Thus, the government in its well known wisdom could control the flow of resources to make the best of all possible worlds.

Mr. Daly also had neat schemes to persuade the masses not to have too many children. Adopting an idea of economist Kenneth E. Boulding, Mr. Daly proposed transferrable birth certificates, which apparently would be purchased on the open market by people who wanted to have babies. One wonders whether Mr. Daly would apply this idea to the U.S., where the birth rate has already dropped below replacement levels, or to India, where political chaos and illiteracy would probably doom it from the start.

As usual, the limits-to-growthers trotted out their warnings of mass starvation, revolution, wars over natural resources and political and economic upheaval; and they waved the (usual, valid) banners of reduced population growth, alternative power sources, more modest technology, and countries living within their resource means. Perhaps these were new ideas to the conferees, but only if they had been living in Texas for the past five years.

Meanwhile, in the outside world there was the rising belligerence of the poor nations of the world, who are beginning to complain that limits-to-growth in reality means limiting *their* growth. This voice was heard but faintly within the Woodlands.

The chief growther at the conference was Herman Kahn of the Hudson Institute, whose discussion paper (distributed to the press) cautioned "this document is not for distribution or publication, and it should not be cited or quoted without the permission of the author. Hudson Institute Discussion Papers . . . do not necessarily represent the considered opinions even of the author."

So, Mr. Kahn cannot be reported on here, except to say he was optimistic.

Science correspondent Nicholas Wade (November 7, 1975) perhaps best summarized what seemed to be the ambience of the conference: "Limits-to-Growth '75 made a good beginning, but its successor should probably give more time to hard analysis of stationary state economics, and less to the mushy visions of semi-professional futurologists . . . " — *D.M.*

OCEAN TECHNOLOGY

Whose Nodules Are They?

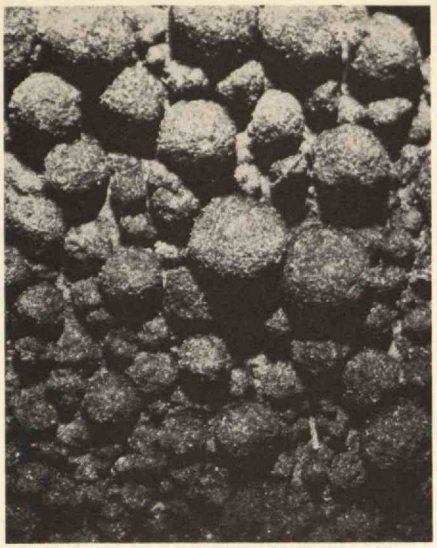
The draft treaty prepared for the Law of the Sea conference which convenes at the U.N. this spring is a truly radical document, "deeply infiltrated" with "the new economic order," thinks Leigh S. Ratiner, Administrator of the U.S. Department of the Interior's Ocean Mining Administration. He has been a U.S. participant in both previous Law of the Sea conferences.

In the draft, the developing countries insist that all resources which lie beyond territorial limits belong equally to all; the "prerogatives of equity" simply aren't recognized, said Mr. Ratiner. "And if the developing countries persist in this revolutionary approach," he declared, "then there is no chance that the U.S. can agree."

One line of opposition to this revolutionary view comes from "a curious alliance" of developed and developing nations (Canada, Russia, Australia, Rhodesia, and South Africa) Mr. Ratiner said in his Sea Grant Lecture to M.I.T. this fall. The common denominator binding these unlikely partners: each has substantial land-based resources of nickel, and none wants to lose a market for these resources to the nickel-rich nodules which pave the Pacific floor from Hawaii to Baja California.

The crucial question for the U.S., thinks Mr. Ratiner, is whether our deep-sea industry will be so discouraged in its quest for these riches as to abandon its investments in the technology for their recovery or, more likely, export that technology to some other nation which can better exploit it.

"We cannot risk that capability," said Mr. Ratiner; and so he holds out the eventual possibility of unilateral U.S. action to



Nodules cover the sea floor in some areas, and seem to be a rich source of nickel, copper, and cobalt, as well as manganese. But questions of territory and technology may prevent their recovery. (Photo courtesy of B. C. Heezan, Columbia University.)

exploit extra-territorial undersea resources.

Nothing would more please John E. Flipse, president of Deepsea Ventures, Inc., which since 1968 has been developing technology to recover and refine the elusive Pacific nodules. It's an uphill fight, he said in his Sea Grant Lecture; at least $500 million will be needed to put a single mining production on the ocean — each operation requiring a ship, dredge, and three-mile-long pipe strung between them; a transportation system to bring nodules from ship to shore; and port facilities and a refining plant to receive and process the result.

Mr. Flipse exudes optimism. Research on the nodules convinces him of their value as sources of nickel, copper, cobalt, and manganese. Now he needs only permission to dredge up his prize, and investor's money to launch the enterprise. It's clearly no get-rich-quick scheme; but "financiers can't tolerate uncertainty," says Mr. Flipse, "like, whose nodules are they, anyway?" — *J.M.*

Oceanography Seeks the Unseeable

When you seek data from the depths of the ocean, you are playing a game of blind man's bluff: you cannot see what you are doing, where you are doing it, or the environment in which you are working. A major effort of oceanographers and marine technologists, then, is devoted to the search for ways to observe and measure what they cannot observe for themselves below the surface of the sea.

Here are some current examples from the 1975 annual meeting of the Marine Technology Society:

— A moored environmental profiler, described by George F. Hickey, Jr., of the Naval Research Laboratory, consists of pressure and temperature recorders which move freely along a 3,000-foot polypropylene line along one end of which is a 500-pound anchor. Let the line overboard until the weight rests on the bottom; then drop the recorders down the line. When they reach the bottom, energize a gas generator to provide enough lift to bring the sensing recorders back to the surface. When the job is done — many descents and ascents along the line are possible, since up to 64 gas generators are provided — Send a signal to a deep-sea acoustic receiver which cuts the line above the anchor; everything but the anchor is recovered.

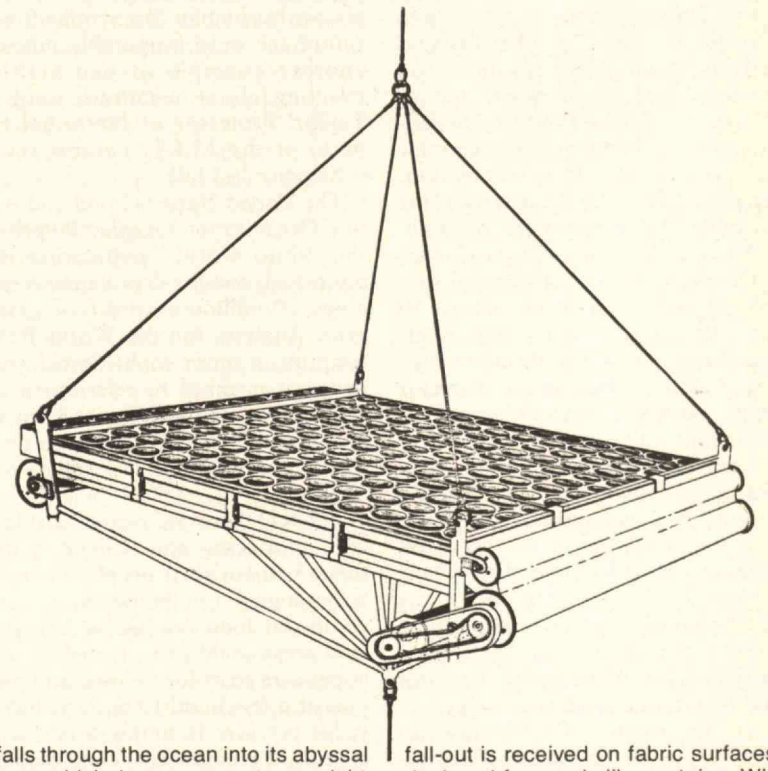
— To analyze the rate and nature of sea floor sedimentation, Roderick S. Mesecar and Andrew G. Carey, Jr., of the Oregon State University School of Oceanography, will locate their *in situ* sediment collector just above the sea floor on a line between an anchor and a float. The collector has three surfaces, each 4.5 square meters. Let sediments fall on one surface for a month; then roll up that surface and deploy the second to receive another month's input of particulates. After all three surfaces have been exposed, cut the anchor line and retrieve the collector.

— Drop a missile containing accelerometers and trailing a line from a research ship through several hundred feet of water into bottom sediments. The accelerometers measure the resistance encountered by the missile in terms of its deceleration at various depths. Occasionally drop a coring device nearby to sample the bottom sediments. Retrieve the missile and correlate the deceleration data with the cover to learn about sedimentation patterns. (In 1971 six such penetrometers were released from the research vessel *Alaminos* in up to 720 meters of water in the Gulf of Mexico. The telemetry failed, and no deceleration data were obtained. Back to the drawing board.) — *J.M.*

The Sad State of Ocean Study

Only during and after World War II did the most developed nations of the world begin to understand the basic importance and complexity of the world ocean. Twenty-five years later there are still more questions than answers — and, said a series of speakers at this fall's annual meeting of the Marine Technology Society, there is no program for resolving a long shopping list of unknowns.

Here is such a list from Harris B. Stewart, Jr., Director of the National Oceanic and Atmospheric Administration's Atlantic Oceanographic and Meteorological Laboratories, and others



What falls through the ocean into its abyssal depths, on which deep-sea creatures might be nourished? Seeking an answer, Roderick S. Mesecar and Andrew G. Carey, Jr., of Oregon State University have built this benthic particle collector. The ocean's fall-out is received on fabric surfaces deployed from rods like curtains. When its three fabrics have been exposed — each for a month or more — the device is retrieved and its contents analyzed.

at the M.T.S. keynote session in San Diego:

— Detailed maps of the ocean floor are lacking for most parts of the world.

— The present state of the art makes possible positioning a ship at sea only to within ± 180 meters of a desired place. When sea floor mining begins that will have to be improved six-fold, to ± 30 meters.

— National boundaries are unmarked at sea; sea floor markings are essential if sea floor resources are to be utilized.

— Fundamental knowledge is still inadequate to explain processes at the sea-air interface.

— Environmental constraints can only be estimated; we simply have to guess at the environmental stress of many potential pollutants and activities.

— Supertankers, container ships, LNG tankers, automated dry cargo carriers — a "dramatic change" in ships since the 1960s. But there are no comparable changes in ship salvage methods, and indeed no studies of salvage systems for exotic new craft.

— The shoreline is "where the action is," where nutrients from land and sea mix, where special interests — recreation, commerce, and industry — confront each other. Yet both fundamental knowledge and management priorities are inadequate for shoreline policy.

Most oceanographic instrumentation today has had a "serendipitous origin," said Don Walsh of the Naval Material Command. Heterogeneous exploration has characterized man's attacks on every frontier except space; must it continue to be so for the oceans? There has been no national inventory of port facilities and future needs, said Mr. Stewart; and — after blossoming in the 1960s — the federal program for building oceanographic research vessels has lost momentum. Submersibles "are by far the best tool" for certain kinds of oceanographic research, thinks Auton L. Interbitzen of the University of Delaware; but today's fleet of submersibles is under-utilized by at least 50 per cent. Altogether a "sorry state of affairs" in ocean policy and ocean management, said William Nierenberg, Director of Scripps Institution of Oceanography.

A dissenting vote from David S. Potter, Undersecretary of the Navy. When they talk like this, oceanographers are in some sense asking the government to make their decisions for them; and in another sense complaining about decisions which have already been made. Only if the U.S. elects to make itself once more a world maritime power can a consistent, centralized policy be marshalled in Washington, he said; and that is not a national goal today.

Robert A. Frosch, who has just returned from the United Nations Environmental Program in Nairobi to become Associate Director for Applied Oceanography at Woods Hole Oceanographic Institution, responded that this set of "remarkably discouraged" oceanographers and engineers were talking about the wrong problems. He agreed with Dr. Potter: though the variety of ocean research and marine technology testifies to the lack of a monolithic plan, it also prevents monolithic mistakes. For that reason, and because the flow of oceanographic information is now very great, scientists should not expect to turn the clock back to the post-World-War-II days when detailed, long-range planning was needed and effective.

And the real issue today is a more fundamental one: we persist in studying the seas as a source of extractable resources; indeed, the question before the Law of the Sea conferences is how to divide up these resources. But that is a short-sighted view: the true question is not how and under whose auspices the sea is to be depleted, but how the world ocean is to be managed for all peoples of the world on a sustainable-yield basis, said Dr. Frosch. — *J.M.*

FOOD

The Constraints Are Not in Technology

True, there are malnourished, poverty-stricken humans on every continent of the globe today, and most of them are in those parts of the world where birth rates are highest. But the belief that world population outrunning world food supply, with a human catastrophe from starvation the only foreseeable outcome, is another example of neo-Malthusian thinking about resources, said Lance Taylor, Professor of Nutrional Economics, at the M.I.T. natural resources conference last fall.

The United Nations Food and Agriculture Organization says that 20 per cent of the "third world" population is malnourished, and the deprivation represents about 20 million tons of food grains per year. Analysts for the World Bank, attempting a more sophisticated study of personal incomes in relation to calorie deprivation, set the deficit at 35 to 45 million tons. This is but 3 per cent of total food grain output (1,250 million tons) in 1973.

Though there are practical difficulties with producing and delivering food to these malnourished people, there are no technological roadblocks to this modest additional food production. Agricultural land areas could be increased 50 per cent at per acre costs for clearing and preparation of a few hundred dollars. Increasing yields per acre is simply a matter of increasing the expertise — and perhaps the machinery — of millions of undereducated peasants. There is no world water shortage — only a failure to use all available resources efficiently. Energy is in fact a modest input to most agricultural systems, and the general price level is closely tied to the cost of energy so a farmer's income is likely to go up as his outgo increases.

If the problem is not technological, how about other kinds of government interventions? New foods — notably protein fortification — have been a common response. But no one is now sure whether the problem is protein malnutrition or general malnutrition; and protein fortification adds cost which probably offsets the benefits, thinks Professor Taylor. Population control? Increasing food production may be easier to arrange than decreasing births, and there is some suggestion that economic growth (including food production) responds positively to population pressure, said Professor Taylor. More efficient use of food in the U.S. — i.e., less use of grains for inefficient beef production? The first result is likely to be curtailed grain production to avert falling prices; "the only problem is getting someone to pay for . . . the grain hypothetically not used in feed lots."

All this leads Professor Taylor to discard neo-Malthusian arguments about population control and resource limits, and instead to equate malnutrition with "the deep social causes of underdevelopment . . . The most effective means of grappling with undernutrition," he said, is "some sort of income redistribution" — land reform, food programs, even revolution. "The focal changes will have to be in the social relationships of people to technology and among themselves." — *J.M.*

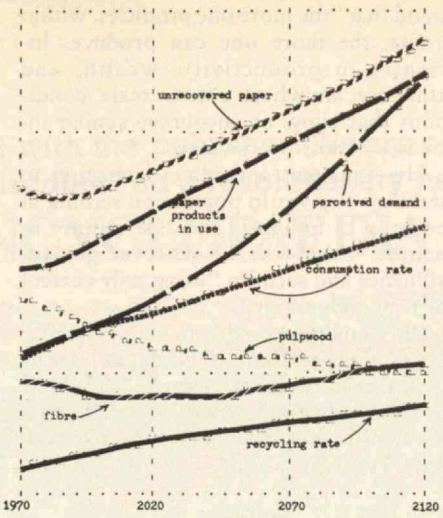
RESOURCES

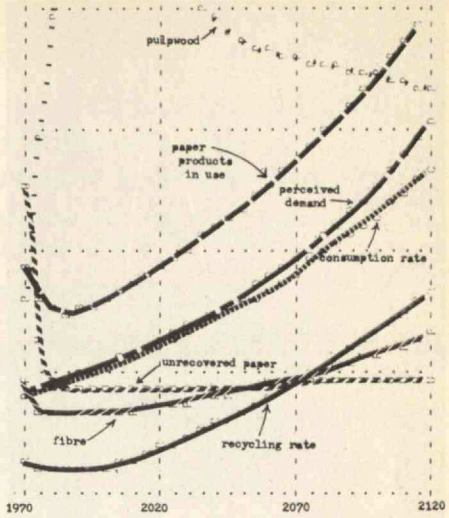
Why Not More Recycling?

Paper demand is increasing at more than one per cent a year, and fiber requirements are prodigious. But recycling — which seems to have the dual advantage of reusing a potentially scarce resource and reducing expensive waste management — is a relatively small factor in the industry. Perplexed because the industry does so little of what their intuition led them to think it should do, E. Robert Miller and Eliot W. Goldstein of M.I.T., invoked the method of system dynamics pioneered by Professor Jay W. Forrester of M.I.T.'s Sloan School of Management for studying industrial, urban, and social systems.

Their first task was to devise a model — based on a similar model of solid waste systems originally published in *Technology Review* (March/April, 1972, p. 23) by Jørgen Randers and Dennis Meadows to show the interrelationships between the factors which seem to be important: the supply and price of virgin and waste fiber, the cost of processing waste

Why is so little paper recycled in the U.S.? And what policies might lead us to be more frugal of our papermaking materials? Seeking the answers, E. Robert Miller and Eliot W. Goldstein of M.I.T. constructed a computer-based dynamic model of the paper industry. The "standard run" (left) reveals that even by the year 2120 recycling will be a small factor in the paper industry if it continues to operate in today's image; but technological improvements in recycling and papermaking, together with a 50 per cent tax on paper products from virgin fiber, yield a markedly higher recycling rate and a balance between supply and demand (right).





fiber, the demand for paper, the nonmonetary cost of waste disposal. Using this model, they studied the recent history of paper recycling. They confirmed the model by making sure that it was consistent with the recent history of the paper industry, including recycling; then they used it to look into various alternative futures as demand increases and pulpwood supplies decrease.

According to Messrs. Goldstein's and Miller's model, if there are no substantial policy changes, growing paper demand in the future will be filled largely as it has been in the past: by virgin paper products used once and discarded. The supply of fiber will constrain production by the year 2120, so prices will rise; but recycling will continue to be a modest factor in the industry. Even new technology yielding a reduction of 50 per cent in the cost of recycling — assuming that recycled fibers are processed by today's methods — would have little effect on the industry's dependence on virgin fibers.

But two other technological developments turn out to be more promising: if papermakers can find ways to use higher proportions of recycled fibers to make quality paper products, and if a higher proportion of the fiber in waste paper can be salvaged in more efficient recycling processes, then the recycling rate rises dramatically.

A single government intervention is suggested: a 50 per cent tax on products made from virgin fiber, which has the effect of making recycled fiber more economically competitive.

Given these three developments acting in concert, the model proposes a 75 per cent reduction in unrecovered waste paper, a 100 per cent increase in recycling, and a 65 per cent reduction in the differential between paper supply and demand which the model postulates for the year 2120. — *J.M.*

Resources: The Future Need Not Be So Different from the Past

Few resources are truly infinite. But earth's riches are far from exploited, or even understood; returns on investments in technology have barely begun; and remarkable incentives for further exploitation are built into the system.

This from six members of the M.I.T. faculty who spoke to a San Francisco seminar for the M.I.T. Club of Northern California late in September — and from a score of speakers at the American Mining Congress the following week.

No sudden "doomsday" lies ahead, they said, and our world need not be so different in the future from the past.

No Market Manager, Little Need for One

Mankind today is in the same position on earth as may have been a crew of Roman soldiers shipwrecked on an unexplored Mediterranean island, Professor Robert M. Solow told the M.I.T. seminar: we do not know what resources we have, or how soon rescuers — our ingenuity — will bring us more.

In our system, sacrificing current consumption for future value is called investment. Society's investments in education and defense and the contents of the accumulated volumes in our libraries can be thought of in this way.

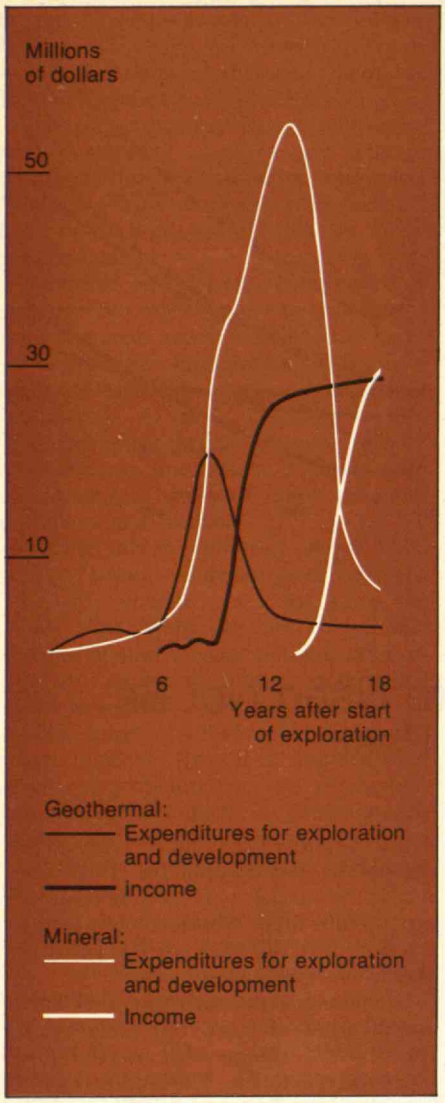
Conservation of mineral resources can also be considered an act of investment, and it can be justified by the expectation of profits which will result from sacrificing current consumption for future value. The market's response is to place a low value on this investment opportunity, said Professor Solow. Resources represent perhaps five per cent of the value of total world output (75 per cent is labor, 20 per cent plant and equipment). Read correctly, the market tells us that resources are a minor input whose role we tend to overemphasize, and whose shortage should not cause panic.

Irreplaceable minerals and fuel are a special kind of asset, but future value (profits) still equate with social return, said Professor Solow. The market is working day in and day out to tell us that shortages are few, resources plentiful, substitutes available — with some exceptions.

Our consumption of resources such as clean air and water is not governed by any obvious balance between the values of investment and consumption, he agreed. So, too (perhaps), the case of a few critically scarce resources whose future value may be greater than we can recognize today. We need a policy which puts a market value on clean air and water and an analytical system to help us recognize absolute, critical shortages a decade in advance, when we can understand alternatives and their costs, argued Professor Solow. Government environmental programs and government commitments in research and development without government intervention — at least until the crucial decade arrives — are the key in the management of supply and demand.

Herman Kahn, President of the Hudson Institute, calls this a "post-industrial" or "super-industrial" position, and he contrasts the "neo-Malthusian" position of those who propose to limit growth to be consistent with any present concept of a finite world.

"Neo-Malthusian" thinkers, he told the American Mining Congress, fail to under-



A short lesson in mining economics — as provided by Harry J. Olson and William M. Dolan of AMEX Exploration, Inc., at the 1975 American Mining Congress — makes geothermal look like an investment of opportunity. Assuming discovery of comparably viable geothermal and mineral resources in the fourth year of exploration programs, the geothermal prospector will spend perhaps $20 million within five years to develop production. A mineral deposit would require eight or ten years and $50 million for development, but exploration costs would have been low compared with those of geothermal. But all this is only half the picture, and the AMEX geologists describe geothermal as "an attractive flower trying to survive in a bed of weeds." Sixty per cent of geothermal resources are estimated to be on federal lands, and federal leasing policy has been uncertain and even perverse. The absence of tax incentives — "traditionally accorded to an emerging industry," said Messrs. Olson and Dean — "has virtually dried up the traditional sources of risk money." They conclude that the goal of geothermal resources equivalent to one million barrels of oil by 1985 "is patently impossible."

stand that "the more one produces, within limits, the more one can produce. Increases in productivity, wealth, and affluence anywhere often create conditions that allow or encourage similar increases almost everywhere."

His argument anticipates transition to stability — a world population settling at perhaps 15 billion in the 21st century as people everywhere achieve greater affluence and security "using only current or near technology."

"It would be possible to support world populations of 20 or 30 billion at least by typical middle class standards." It will be a "post-industrial society . . . close to a humanistic utopia by most historic standards," said Dr. Kahn.

The O.P.E.C. Illusion

Neo-Malthusians have helped us by focussing attention on a little understood problem. But for himself, said Howard W. Johnson, Chairman of the M.I.T. Corporation in San Francisco, "lack of growth imposes constraints as serious as those of growth." Many speakers at the American Mining Congress were less generous, suggesting that premature estimates of a finite world's limits may upset the system which could otherwise guide us to Dr. Kahn's "humanistic utopia."

Today's malaise in the copper market results from "limited" thinking, according to Simon D. Strauss, Executive Vice President of Asarco, Inc. Speculators invested so heavily in copper inventories, seemingly a good investment on the basis of reported diminishing ore resources, that in 1973 the price of copper in the London commodity markets was up to $1.52 per pound (from 50 cents in 14 months). But by April, 1974, surging demand in the face of scarcity had failed to materialize, Mr. Strauss told the American Mining Congress; copper inventories turned into copper surpluses, and the price, despite inflation, is now so low as to be "well below" the cost of production in many mines and low enough to bring copper once more into competition with aluminum for electrical conductors.

If such market antics can be attributed to an uncritical acceptance of neo-Malthusian ideas, then orderly mineral markets may in fact be in jeopardy in the future.

The O.P.E.C. nations' success in dictating the world price of oil may be to some extent due to a neo-Malthusian illusion, Professor Solow added. There is nothing scarce about petroleum today, and the O.P.E.C. cartel is in fact far from free to set its price at its pleasure. "It's not as if the barrel will suddenly be empty," said Professor Solow. "It's my prejudice that we tend to scare too easily about shortages."

Thomas V. Falkie, Director of the U.S. Bureau of Mines, is of the same mind. Though he presented to the American Mining Congress a list of 18 minerals for which U.S. cumulative demand to the year 2000 exceeds present U.S. reserves ("the problems of resource and reserve inadequacy stand out as the major trouble spots" before 2000, he said), he advocates free access to raw materials and free trade in minerals. He regards the threat of an O.P.E.C.-style boycott of minerals as not serious: suppliers are geographically and politically diverse and their income needs are urgent, he said.

Economics of Ecology

Environmental controls have reshaped U.S. mineral industries in a decade, and anyone eavesdropping even briefly at the American Mining Congress would sense an adversary relationship between "economy" and "ecology." Frederick E. Templeton, Assistant to the President of Kennecott Copper Corp., for example: "We will soon reach a point where technical and economic decisions of businesses are being made by administrative agencies which have only a narrow perspective on the overall consequences of these decisions. . . . There has not been any meaningful effort to approach air pollution control from a cost-effective standpoint."

To some in her audience of mining and mineral industries executives, then, Beatrice E. Willard of the Council on Environmental Quality must have proposed a heresy: "economics" and "ecology" two words from the same stem?

True, and even today, said Dr. Willard, "the two disciplines can complement each other in function and results." As J. Herbert Hollomon, Director of the M.I.T. Center for Policy Alternatives, told the M.I.T. seminar, when government intervenes in the resources markets (as it must to put a price on "free" pure air and water), let it benefit from the leverage of the free market system.

We tend to seek what Dr. Hollomon calls "quick fixes," to legislate simple solutions to complex problems — absolute limits, or the concept of "best available control technology" when limits cannot be devised. Professor Solow favors more flexible, ambiguous solutions: a tax on pollutant emissions, for example:

— When we tax pollutants we attain some measure of understanding of the cost of our ideals, and we can adjust our goals according to our means.

— The simplest, least costly ways of reducing pollution will be chosen first, so that as a whole we will be sure of achieving most relief for least money.

A curious anomaly, observed Dr. Hollomon: we profess to believe in a complex, decentralized economic system in which market forces determine price and demand determines supply; we seek to regulate it with centralized controls which promise to make complexity go away. The lesson is clear — no government can decide how resources are to be allocated to a free industrial system without jeopardizing that system's freedom. — *J.M.*

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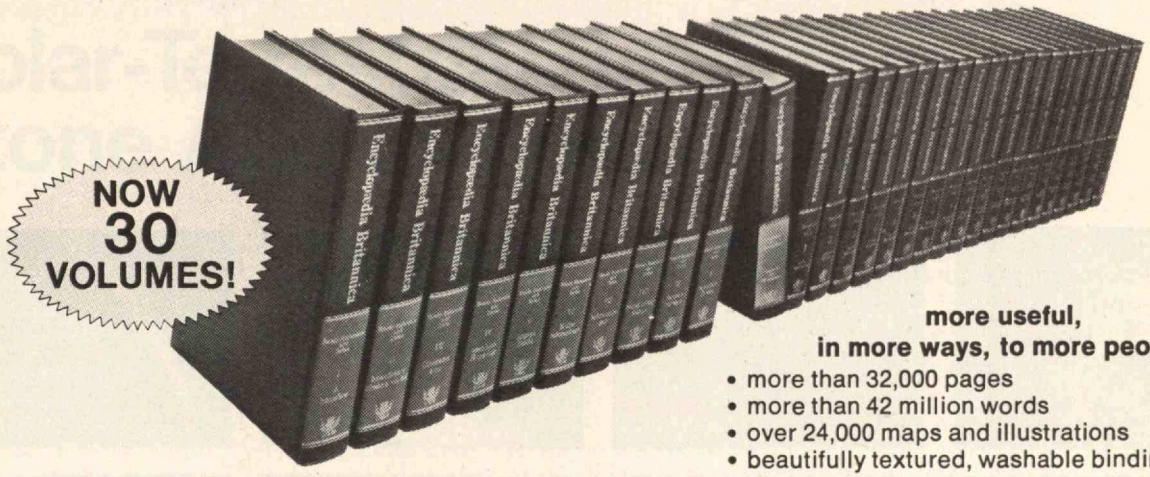

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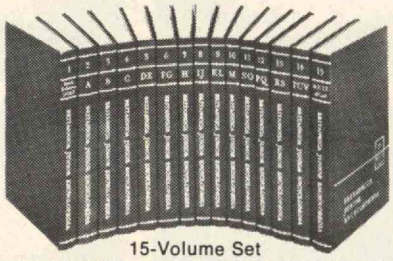

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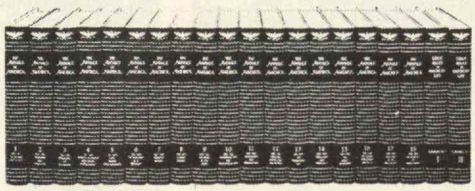

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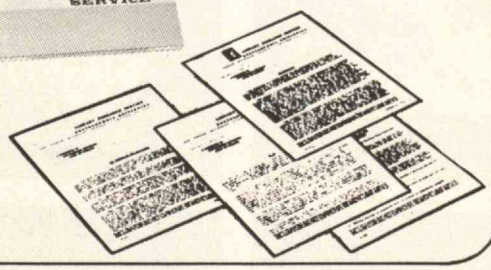

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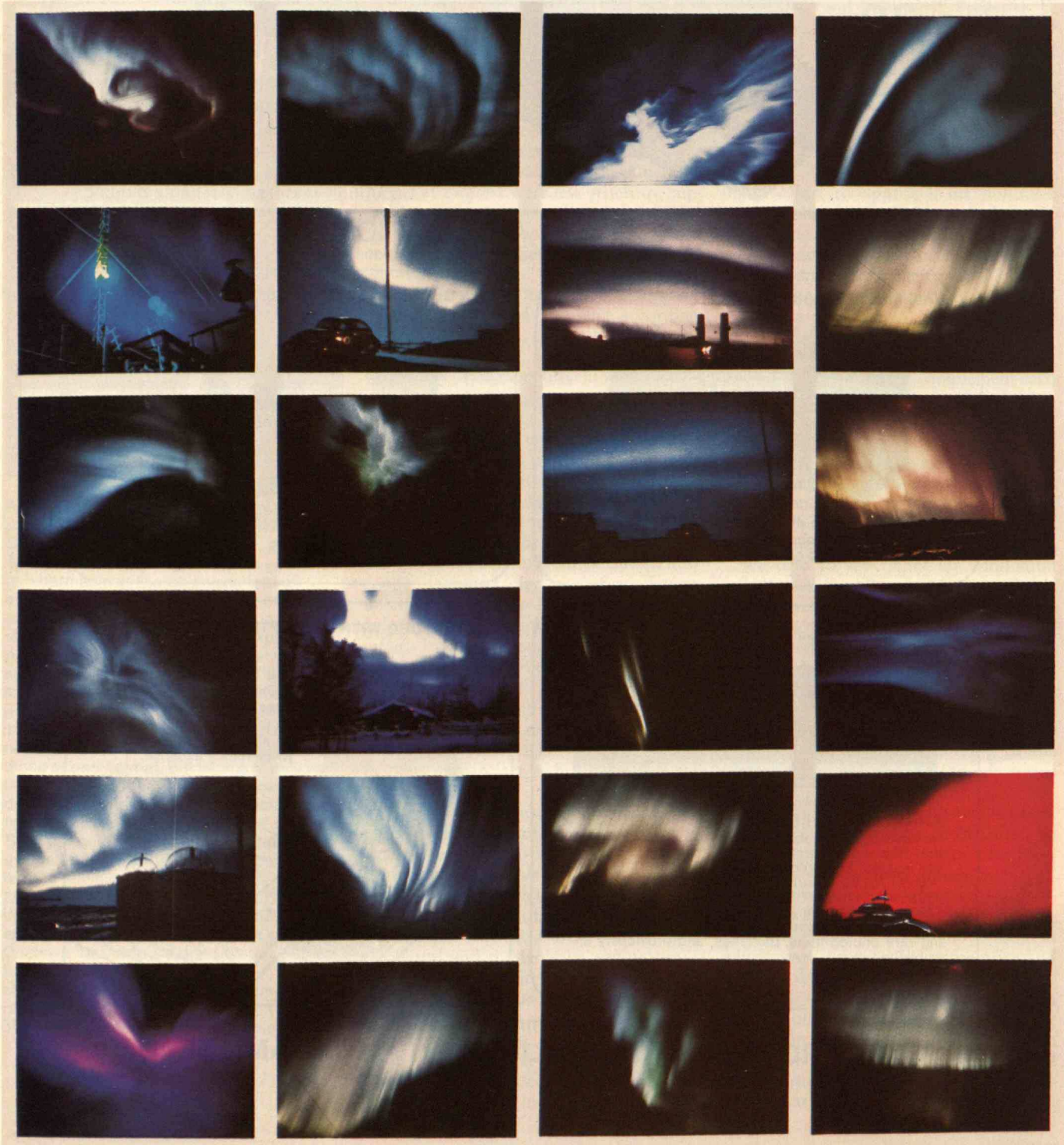
When the earth's magnetic field diminishes in intensity, auroral displays become far more spectacular — as has happened several times since man emerged.



George L. Siscoe
Professor of Meteorology
University of California,
Los Angeles

Solar-Terrestrial Relations: Stone Age to Space Age

We live in uninteresting times, at least with regard to heavenly phenomena. Compared to some earlier (and also some future) ages, our night sky is quiet and colorless over most of the earth. Of course we get our share of meteors and comets; and there are even places where almost every night presents mobile color displays on a sky-wide scale. These special regions, forming bands between 65° and 75° latitude in each hemisphere, are the domains of the *aurorae borealis* and *australis* — the northern and southern lights. The lower latitudes where most people live host auroral displays only rarely, but this was not always so in prehistoric times. Studies from the field of geology on the changes in the earth's magnetic field in the past and studies from the field of space science on the way aurorae are produced have evolved to a point where they can now be combined to give a description of auroral phenomena over geological time. The results may have applications to studies of early man: in periods when the aurora was common in populated latitudes, he may have made it part of his religion and other aspects of his culture.

Solar-Terrestrial Relations in Historic Times

Most of the energy given off by the sun is sunlight — electromagnetic radiation in the visible part of the spectrum — which drives the motions of the lower atmosphere and the oceans, and is the ultimate source of nearly all the energy used by man. It may seem anomalous, therefore, that the label "solar-terrestrial relations" has come to refer to ultraviolet, X-ray, and particle emissions from the sun, and their effects on the earth's upper atmosphere. But the intensity of sunlight has been constant for at least the 70 years it has been measured, while solar-terrestrial effects vary in time. Also, whereas sunlight travels directly from the sun to the earth, particles that make up the solar wind are ionized as they escape from the sun, and thus being electrically charged, suffer a complicated interaction with the earth's magnetic field. Some of these particles finally enter the atmosphere along magnetic lines of force, and penetrate to about 100 kilometers above the surface. In the process, they ionize and excite atmospheric gases — notably oxygen and nitrogen atoms — which then emit the characteristic light of the aurora. The vigor with which all this occurs depends on the level of solar activity — a level that increases and decreases in an 11-year cycle, is commonly measured by the number of sunspots, and is accordingly called the sunspot cycle. At the peak of solar activity, the number of sunspots, the frequency of solar flares, and the number and severity of auroral and magnetic storms on earth all reach their greatest values.

The many forms, colors, and movements of auroral displays have attracted the interest and curiosity of mankind from prehistoric times to the present. These photographs by Professor Robert H. Eather of Boston College and George Cresswell, formerly at the University of Alaska, are part of a large collection assembled by Professor Eather; they have been chosen to suggest the variety of auroral forms and colors. Most were made on High-Speed Ektachrome film with diaphragm settings of f.1, exposures of one to five seconds.

The region of space where the earth's magnetic field controls the behavior of charged particles (the magnetosphere) is a very dynamic place: solar events cause day-to-day changes, with the regular 11-year sunspot cycle determining the "seasons." Thus, solar storms, their associated magnetic and auroral events, and the sunspot cycle make up the history of solar-terrestrial relations. The following is a summary of this history.

The earliest known reference to a sunspot is attributed to a student of Aristotle, Theophrastus of Athens (ca. 370-290 B.C.). Chinese records note the occurrence of at least 112 outstanding naked-eye sunspots in the period 28 B.C. to 1638 A.D. They were generally regarded as being heavenly comments on the affairs of state, as in this passage referring to an event in 374 A.D.:

On a keng-yin *day in the third month of the third year, two* hei tzu [*sunspots*] *of the size of duck's eggs were observed. At that time the Emperor had already attained manhood, yet the Empress K'ang-Hsien, the sister-in-law of the Emperor, continued to attend to state affairs. This was against the Tao and hence defects were manifested by the sun.*

In the 1940s D. Justin Schove of St. David's College, England, undertook a major search of the Oriental and Occidental historical records of sunspots and aurorae. He was able to locate the times and estimate the magnitudes of sunspot maxima for each cycle back to 300 A.D., and, with a few gaps, back to 649 B.C. The cycle had an average period of 11.11 years, although the length of individual cycles varied from nine to 14 years. The maximum activity of each cycle varied considerably over the record. One curious situation occurred during the last half of the 17th century when sunspots were so rare that the interval was dubbed "the great sunspot minimum." For one of the cycles in this period, sunspots were essentially absent. The most recent cycle, with its maximum in 1969, was

Solar and geomagnetic variations over the past 20 million years are shown in five telescoping steps. Top field: sunspot numbers from 1755 to 1969 A.D. reveal the 11-year sunspot cycle. Second field: auroral activity on a relative scale that compares the maxima in each sunspot cycle since approximately 600 B.C. as compiled by D. J. Schove. Third, fourth, and fifth fields: paleomagnetism as measured in deep-sea cores by N. D. Opdyke. The third field records paleomagnetism over the past 27,000 years. The fourth records paleoinclination — the angle that the field makes with the ground at the location of the core. The rightmost two-thirds of the curve cover the so-called Brunhes normal epoch, which began 700,000 years ago and is continuing. In this period, the dipole has generally retained its present orientation, though there have been several "brief" excursions, the most recent of which is the Laschamp event, occurring in Paleolithic times. The fifth field shows paleointensities in a core that records magnetic history from the Brunhes epoch back in time to polarity epoch 11, dated at around 20 million years ago. Large decreases in this curve correspond to dipole polarity transitions.

near the middle of the range of activity established by earlier cycles. However, the previous cycle, with its maximum in 1958, was the most active in nearly 200 years.

The continuous rhythm of the solar cycle is punctuated by individual solar storms. They have caused many exceptional auroral displays in historic times. The earliest references to aurora, according to some interpretations, are three passages from the Old Testament: Jeremiah 1:13 (626 B.C.); Ezekiel 1:1-28 (593 B.C.); and Zachariah 1:8 (518 B.C.). The entire first chapter of Ezekiel is a fairly obvious supernatural interpretation of an animated auroral display:

. . . the heavens were opened . . . a whirlwind came out of the north, a great cloud, and a fire enfolding itself . . . [living creatures appeared] their appearance was like the burning coals of fire, and like the appearance of lamps: it went up and down among the living creatures; and the fire was bright, and out of the fire went forth lightning. And the living creatures ran and returned as the appearance of a flash of lightning.

To one familiar with the antics of aurorae, this metaphorical construction seems nearly perfect. (It must nevertheless be admitted that some regard an explanation in terms of visiting gods from outer space as being more reasonable.)

Greek accounts begin with Anaximenes (middle and latter part of the sixth century B.C.) and include discussions by Anaxagoras (born about 500 B.C.) and Aristotle (387-322 B.C.). In Roman times, aurorae are mentioned by Cicero (106-43 B.C.), Livy (59 B.C.-17 A.D.), and Seneca (4 B.C.-65 A.D.). Those seen in low latitudes are commonly red, and consequently, when they appear on the horizon, were often mistaken for a major conflagration. According to Seneca this happened in Rome in the time of Tiberius (37 A.D.), when

. . . the cohorts hurried to the succor of the colony of Ostia, believing it to be on fire. During the greater part of the night the heaven appeared to be illuminated by a faint light resembling a thick smoke.

Even as recently as 1938 in England, an aurora caused the dispatch of fire brigades to extinguish a non-existent fire at Windsor Castle. A red aurora was probably the "blood-colored spectacle" of 349 B.C. referred to by Pliny the Elder as "a terrible portent, a conflagration falling earthward." In most of Europe and China, aurorae were omens of unpleasant things to come. From China, 309 A.D., we have:

On a i-hai *day in the eleventh month of the third year of the Yung-Chia reign-period of [the Emperor] Huai-Ti, two white belt-like vapours appeared, one in the south and one in the north. They started from the ground and ascended the heavens penetrating into [the constellation] Fa [in Orion] in Shen [21st lunar mansion]. A great battle could be expected.*

In 793 we find what is perhaps the earliest known mention of an aurora in England:

This year dire forewarnings came over the land of the Northumbrians and miserably terrified the people; there were excessive whirlwinds and lightnings and fiery dragons were seen flying in the air.

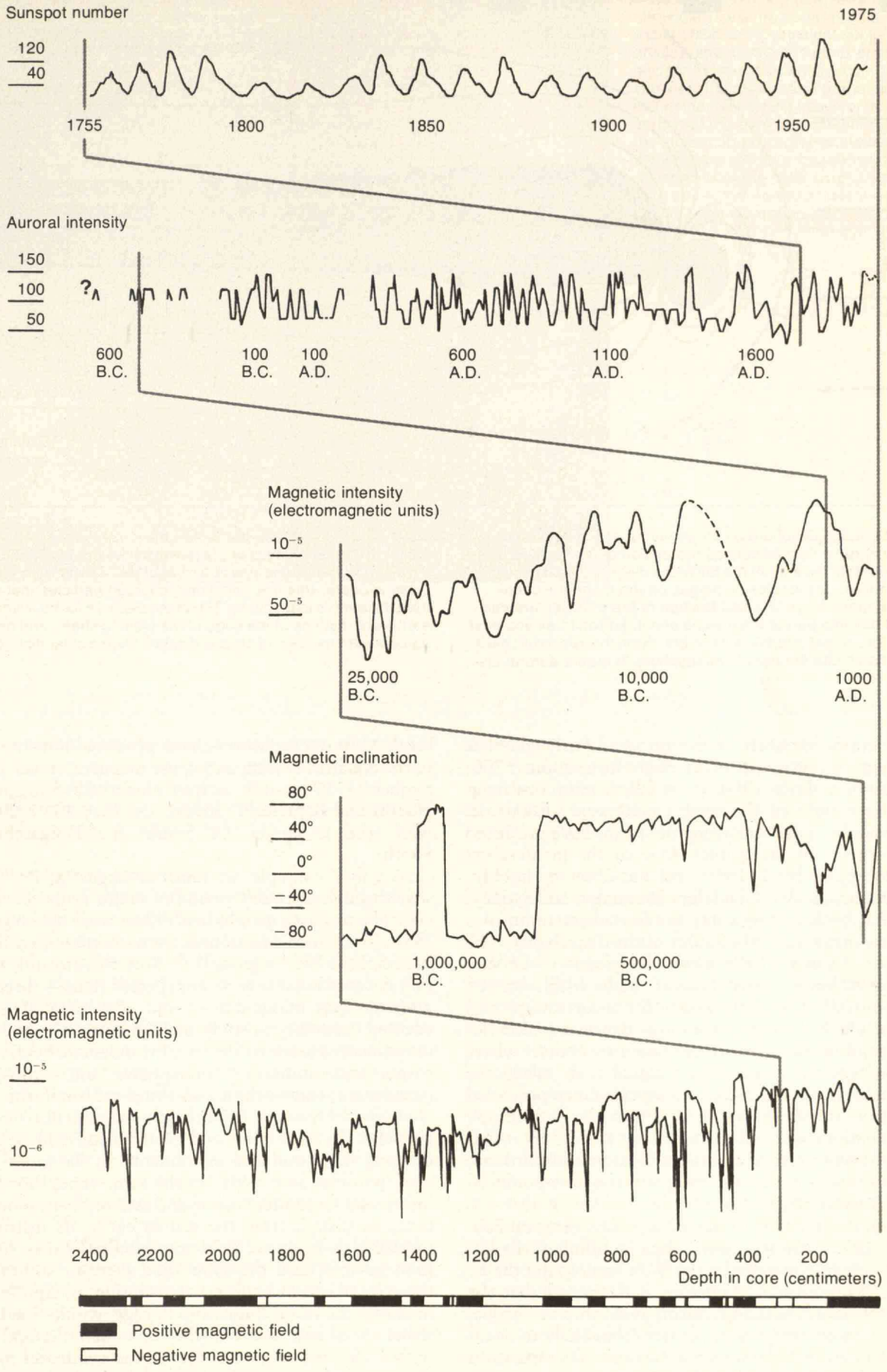
A Czech manuscript from 1571 states:

Fiery pillars were observed above the town of Domazlice about the third hour of the night, and a dragon flying in the air above the whole town from the lower to the upper gate and even beyond the town. I have read somewhere and I was told by my grandparents that this presages murders, fires, and other disastrous events.

In spite of the sunspot drought during the last half of the 17th century, aurorae were observed in England in 1661. These and other portents of the time were collected and distributed by opponents to the Restoration of Charles II (1660) to create the impression that God also disapproved. A tract commenting on an aurora seen in Wales in December, 1661, predicted

. . . the destruction of the King, lawyers, clergy, and citizens of London, with an incitement to the wholesale slaughter of all ruling classes and to firing the city.

The first scientific text to include a discussion of aurorae since the time of Aristotle was written by the French mathematician and astronomer Gassendi (1592-1655), a contemporary of Galileo. He observed a major display in southern France on September 12, 1621, and gave it the name "aurora borealis" — northern dawn. Except for Gassendi, general scientific interest in the aurora in Europe and America began in the 18th century: Edmund Halley (of comet fame) and Benjamin Franklin contributed


Sunspot number
1975
120
40
1755
1800
1850
1900
1950
Auroral intensity
150
100
50
?
600 B.C.
100 B.C.
100 A.D.
600 A.D.
1100 A.D.
1600 A.D.
Magnetic intensity (electromagnetic units)
10⁻⁵
50⁻⁵
25,000 B.C.
10,000 B.C.
1000 A.D.
Magnetic inclination
80°
40°
0°
−40°
−80°
1,000,000 B.C.
500,000 B.C.
Magnetic intensity (electromagnetic units)
10⁻⁵
10⁻⁶
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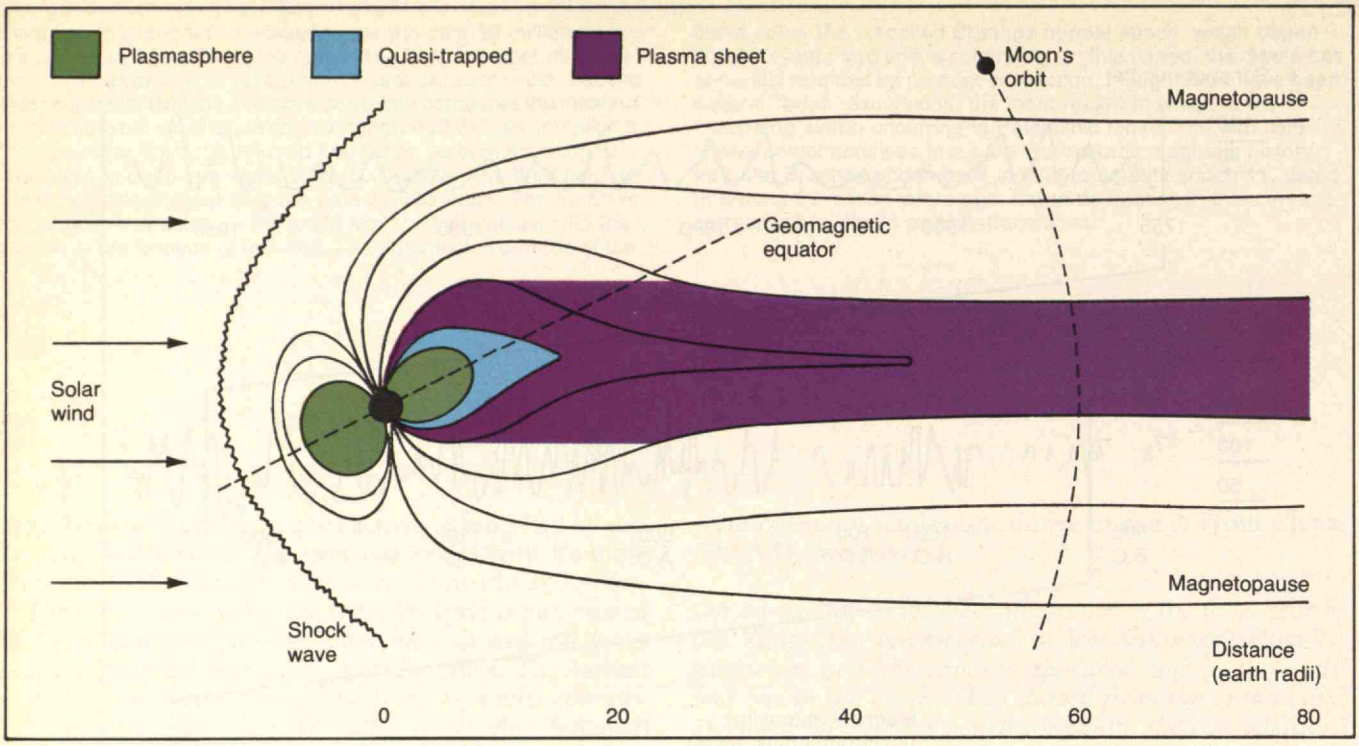
Depth in core (centimeters)
Positive magnetic field
Negative magnetic field

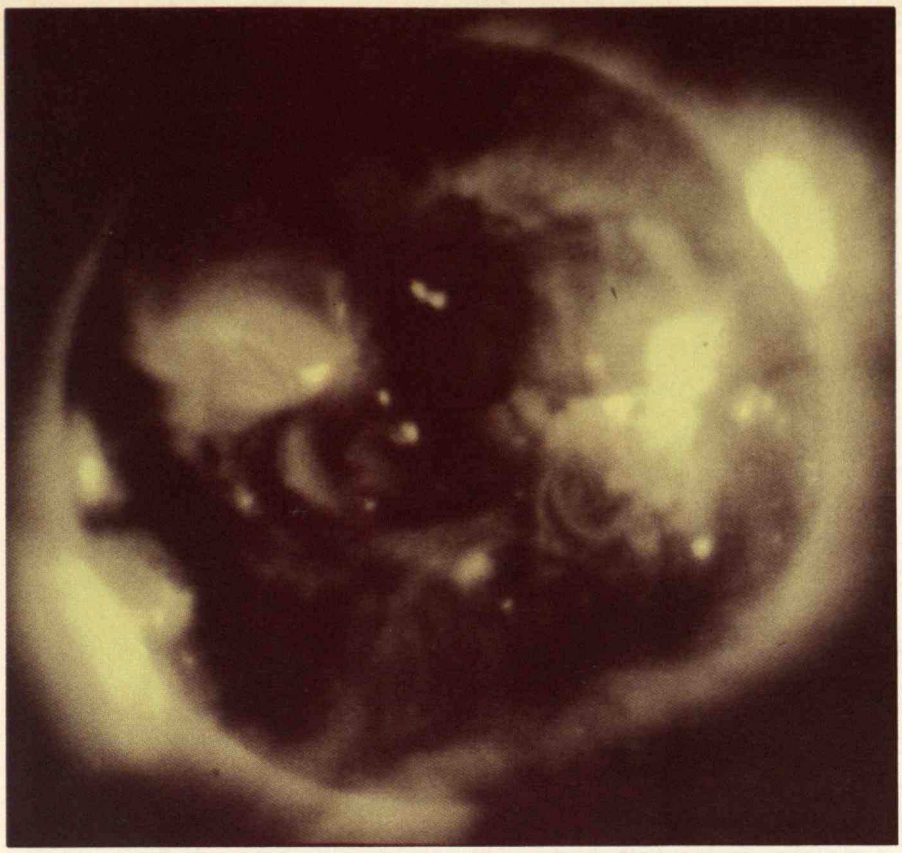


The earth's magnetosphere — the region of space where our planet's magnetic field influences the motion of charged particles that escape from the sun. At the left of the diagram, the solar wind, composed of such particles, impinges on the magnetosphere, creating a shock wave. A small fraction of the particles are captured and become part of the *plasma sheet,* known to extend past the earth for at least 380,000 kilometers. From this reservoir, particles rain down into the earth's atmosphere to create auroral displays. The high-latitude borders of the auroral zones are determined by the outer limits of the plasma sheet; the low-latitude borders are related to the position of another particle reservoir, the *plasmasphere,* this one containing charged particles that escape from the earth's ionosphere. The plasmasphere forms a limit to the earthward motions of the edge of the plasma sheet, and hence to equatorward motions of auroral displays during solar disturbances.

to the scientific literature on the aurora; a fairly complete chronology of auroral displays exists from about 1700; and beginning about 1850, essentially continuous magnetic observations of the earth's field were also made. Since then, about a dozen magnetic storms have produced aurorae visible in the tropics. One of the greatest occurred on September 1, 1859, and was observed in Honolulu, Jamaica, Cuba, Guadalupe, Santiago, and Sydney. It followed by less than a day the first observation of a solar flare, presumably the source of the disturbance. The flare was seen against the total white light of the sun, which is a rare event; most flares are made visible only by filtering out all of the light except for a narrow spectral region in which the flare emission is concentrated. Telegraph communications were disrupted in France, where an account of the storm effects stated that "when the cable was isolated and a conducting substance presented to it, it gave off vivid sparks." In other places telegraph communications were aided: for about two hours it was possible to send messages between Boston and Portland, Maine, without any battery, using only the storm-induced current (Yankee ingenuity).

The best documented of the great storms came on February 4, 1872. Aurorae were seen in Bombay, Egypt, Santo Domingo, Guatemala, the West Indies, and the islands of Reunion and Mauritius. It happened that the peak of this storm occurred during nighttime in Europe. The sky became bright with activity from Sicily to Scandinavia and from Ireland to the Ukraine. Disruption of telegraphic communication was extensive and nearly total. More recent storms have produced aurorae closer to the equator. During an intense magnetic storm on September 25, 1909, aurorae were observed at Singapore (1° North) and Batavia (6° South). On May 13, 1921, they were seen at Samoa (14° South) and Tongatabu (21° South).

As a final example, we jump to August 5, 1972, halfway through a six-day period of major eruptions on the sun. The resulting geophysical effects were not so great as the other storms mentioned; aurorae were seen only as far south as Washington, D.C. Still, this storm is important because it came at an unexpected time — three years after sunspot maximum — and at a time of unprecedented capability to study such an event. Ground-based instruments measured the sun, the magnetic field, the aurorae, and numerous ionospheric and atmospheric parameters; earth-orbiting satellites measured the sun in wavelengths not seen from the ground, and also energetic particles, the solar wind, and the magnetic field; a satellite orbiting the moon and instruments on the moon measured particles and fields. At the same time, Pioneer 10, on its way to Jupiter, was in the asteroid belt, more than twice as distant from the sun as earth. Its instruments measured a magnetic field one hundred times stronger than normal; and the solar-wind detector saturated. If these solar events had occurred during an Apollo lunar mission, the total radiation dosage would have been lethal to all astronauts in the lunar module, and lethal with a 20 per cent probability in the command module. On earth, the magnetic storm disrupted trans-Atlantic



The energy of the sun radiates into space as visible light (in a wide range of wavelengths ranging from infrared to ultraviolet), plasma particles (the solar wind, which is the principal subject of this article), and x-rays and other products of nuclear interactions which occur in the sun's environment. Most of the latter are lost in the intervening space or in the outer portion of the earth's atmosphere; hence the interest in photographs such as this showing the soft (low-frequency) x-ray radiation from the solar corona as seen from above the earth's atmosphere by the Skylab solar observatory on May 28, 1973. (Photo: N.A.S.A. and American Science and Engineering, Inc.)

cable operation, shut down a power-line transformer in Minnesota, and caused the explosion of a 230-kilovolt transformer in British Columbia. We can only wonder about the consequences in today's world of a storm such as that of February 4, 1872.

The Paleomagnetic Record

What determines where aurorae will be seen? Of course the strength of the solar event has something to do with it, but the main agent in controlling where and how much is the earth's magnetic field. Geological research in this century has shown that this field varies, and with it the solar-terrestrial effects that it controls. To determine the past extent of auroral activity, we must therefore look at the geological history of the earth's geomagnetic dipole.

Evidence accumulated especially over the last two decades shows that the dipole axis almost always stays approximately parallel to the rotational axis of earth, but with a misalignment whose present 11° value is about average. The dipole now points south, but the field goes through cycles in which this direction reverses. The time between reversals is very irregular, being on average from 100,000 to 300,000 years — vastly longer than the 11-year solar cycle. Between reversals, the dipole strength oscillates on a shorter, approximately 10,000-year time scale, still long compared to a solar cycle. The earliest date for which the strength of the earth's dipole was calculated using direct measurements was 1835; the field was then six per cent greater than it is now. Since 1835, the measured rate of decrease has been very steady, and if it continues at the same rate, the field strength will reach zero in a little more than 2,000 years. However, on average there are about 20 major oscillations of dipole strength for every field reversal. Thus there is about one chance in 20 that the present trend will continue through zero.

Information on ancient behavior of the geomagnetic field comes from measurements of fossil magnetism in various geological and archeological materials. Volcanic lava, sediments forming the floors of lakes and oceans, and bricks of ancient fireplaces all acquire a permanent magnetic field when they are created, depending on the magnetic properties of the material and on the strength and direction of the geomagnetic field at the time and place of formation. Use of these techniques has given us knowledge of the field's oscillations for nearly 10,000 years: looking backward, we find that the dipole reached a maximum around 600 A.D., descended to a minimum about 3500 B.C., turned around and was still ascending when the continuous record leaves off at 6500 B.C.

For exploring longer periods of time, the cores of bottom sediments returned from oceanographic expeditions are especially valuable. Since the sediments are slowly and continually forming, each core gives a continuous history of the earth's field at the core site. By this and other techniques that use the continuous spreading of ocean floors (the oceanic equivalent of continental drift), the pattern of field reversals is known for the last 70 million years. Reconstructing the *strength* of the field, however, is more difficult. Still, a statistical analysis by M.

Kono of all available values of paleointensities covering the last 10 million years shows a roughly Gaussian distribution — that is, a familiar bell-shaped curve. The average of all values corresponds to a dipole strength 11 per cent greater than the present value. Over the last 10 million years the earth's dipole has apparently been greater than twice its present value for more than 500,000 years and less than half its present value for a similar length of time. For a total of about 100,000 years the dipole was about one-tenth of the present value.

Contributing heavily to the low end of the distribution are the more than 30 field reversals that occurred during the last 10 million years. For the study of solar-terrestrial relations, these are important events in the earth's history. Each reversal occupies a geologically short period of time, typically a few thousand years. This makes analysis of what happens during a transition difficult, and some differences of opinion exist over details. However, a model based on studies of ocean cores by N.D. Opdyke and co-workers applies to at least three reversals bounding long intervals during which the polarity appears to have remained unchanged. The reversals begin with a decrease in dipole strength and a simultaneous motion of the poles to lower latitudes. By the time the poles reach equatorial latitudes the dipole field is smaller than the non-dipole components of the field, which do not change during a reversal. They essentially determine the minimum value that the earth's field will reach, and this is typically 10 to 20 per cent of the normal dipole field. The interval in which the dipole swings across the equator and the non-dipole components dominate is very short, perhaps only a few hundred years. The reversal ends with the poles reaching high latitudes and the field strength restored.

The time between reversals is highly variable. Early studies identified relatively long intervals, on the order of one million years, in which one polarity dominated. Subsequently these interals have been populated by numerous shorter periods of opposite polarity, the shortest of which amount to no more than twitches a few thousand years in length, during which the field goes from dominant to opposite to dominant polarity again. The present southward-dominant interval began 700,000 years ago, but at least four twitches have occurred in this period. They came around 300,000 years ago, 190,000 years ago, 110,000 years ago, and between 10,000 and 30,000 years ago. The most recent of these is most likely a pair of events, one at around 30,000 years, the Lake Mungo (Australia) event; and one at around 12,000 years, the Laschamp (France) event — both named after the locations where they were first detected. Both occurred in recent prehistory — the Upper Paleolithic — and must have produced night-sky phenomena that fascinated many generations of Stone Age man.

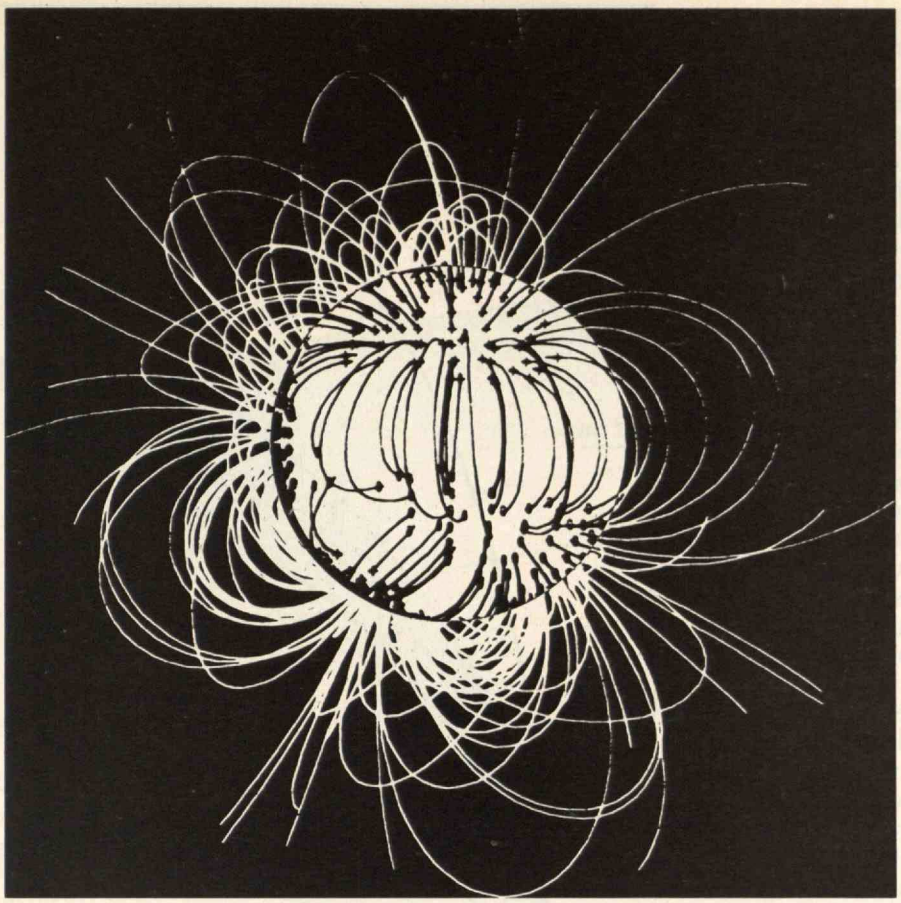
The Aurora Machine

The paleomagnetic record clearly delimits the task for space science: to predict the magnitude of solar-terrestrial relations in the past, any theory must cover a range of dipole strengths from 0.1 to three times the present value, and consider what happens when the earth's field is non-dipolar. And to determine where aurorae were seen in the past, we must look next at what is known about how aurorae are produced in the present.

We may think of the earth's magnetosphere as an aurora machine. It accepts as raw material a certain portion of the solar wind, processes it internally, stores it for a while, and then delivers a product in the form of aurorae to the upper atmosphere. Satellite observations over more than a decade have provided a nearly complete blueprint detailing the parts and structure of the machine. There is also a pretty good phenomenological understanding of how it works, although theoretical understanding is incomplete. We will describe some of the relevant results from space research, starting with the properties of the raw material.

The solar wind consists mainly of protons and electrons in equal numbers, the fragments of atomic hydrogen ionized in the solar corona, streaming away from the sun at speeds between 300 and 600 kilometers per second. At the distance of earth from the sun, the temperature of the solar wind is between 10,000 and 100,000 degrees Kelvin and the density is typically in the range of one to 30 protons (or electrons) per cubic centimeter. The velocity is normally about ten times the speed of sound. An important additional feature of the solar wind is the magnetic field it carries along with it. Originally part of the solar field, this field is in effect trapped by the highly conducting solar wind as it escapes from the sun.

The earth's magnetic dipole acts as an obstacle to the solar wind, and the resulting impact compresses and confines the earth's field to the region known as the magnetosphere. The boundary between the solar wind and the magnetosphere, the so-called magnetopause, begins about 10 earth radii closer to the sun than the earth, and extends comet-like past the earth for at least 500 earth radii. Since the solar wind flow is hypersonic, a permanent shock wave exists upstream from the magnetopause;



The earth's present magnetic field, with the dipole component subtracted out. What remains is a complicated multipole pattern, seemingly random. The pattern may be typical of the earth's total field when the dipole strength diminishes, as happens during a polarity reversal. Such a circumstance seemingly would allow charged particles access to the atmosphere over much of the earth's surface, and consequently would result in nearly ubiquitous auroral displays. The magnetic multipole pattern shown here is that of late June, 1960; the earth is shown with 100° E. longitude at the center of the disc.

it resembles that formed in a wind tunnel when supersonic flow encounters a long, blunt object. The shock slows and heats the solar wind to a temperature near one million degrees Kelvin, and the hot, compressed gas then flows around the magnetosphere. In the process, a small fraction of the gas is captured and becomes part of a large reservoir of energetic particles. The temperature of the gas in this reservoir, which is called the plasma sheet, lies between 10 and 100 million degrees Kelvin.

The plasma sheet has a peculiar geometry within the tail of the magnetosphere. In the plane of the earth's equator it completely crosses the tail, and extends downwind at least 60 earth radii, the limit of present observation. However, in the north-south direction it is sharply bounded inside the tail, so that it forms a long, equatorial slab of hot, ionized gas. The magnetic field in the plasma sheet connects back to the earth, and aurorae result when the energetic electrons stored in the plasma sheet rain down into the atmosphere along field lines. Auroral zones, in other words, are the mapping of the plasma sheet onto the atmosphere along field lines. The nearly particle-free regions between the boundaries of the plasma sheet and the magnetopause also map onto the atmosphere — specifically onto high latitudes where, as at low latitudes, aurora are not often seen. As for the equatorial limits of an auroral display, that border maps out along field lines to the earthward edge of the plasma sheet, which typically lies between 8 and 11 earth radii from earth in the equatorial plane.

During magnetic disturbances, the plasma sheet moves closer to the earth, corresponding to an equatorward motion of the aurora. The earthward motion of the plasma sheet stops, however, at the boundary of another major particle regime of the magnetosphere. This regime, called the plasmasphere, is simply the extension of the earth's ionosphere into space. It is composed of ionized atoms, mainly hydrogen, from the earth's atmosphere, and compared to the plasma sheet it is cold and dense. An interesting and unexpected feature of the plasmasphere is that it has a fairly sharp outer boundary called the plasmapause, whose shape conforms to the geometry of the earth's dipole magnetic lines of force. Its distance from the earth in the equatorial plane is five earth radii on average. Away from the equator, it curves earthward along the magnetic field lines and reaches the top of the ionosphere at an average latitude of 63 degrees. Thus the plasmasphere has the shape of a doughnut with the earth filling the hole in the middle.

The sharp outer boundary of the plasmasphere is due to a wind in the magnetosphere that sweeps away particles; the plasmapause simply marks the distance at which this wind removes particles faster than the ionosphere produces them. The wind in the magnetosphere is driven by the solar wind in a manner similar to the way in which atmospheric wind drives ocean currents; an even closer analogy is the internal eddy circulation in a rain drop produced by friction with the air through which it falls. The strength of the frictional contact between the solar wind and the magnetosphere, and hence the strength of the magnetospheric wind, turns out to depend on the orientation of the solar wind's magnetic field relative to the orientation of the earth's dipole. When the two happen to be parallel the frictional coupling is strong, and in the antiparallel case it is nearly zero. Intermediate cases give intermediate coupling.

Theoretical understanding of this process is good

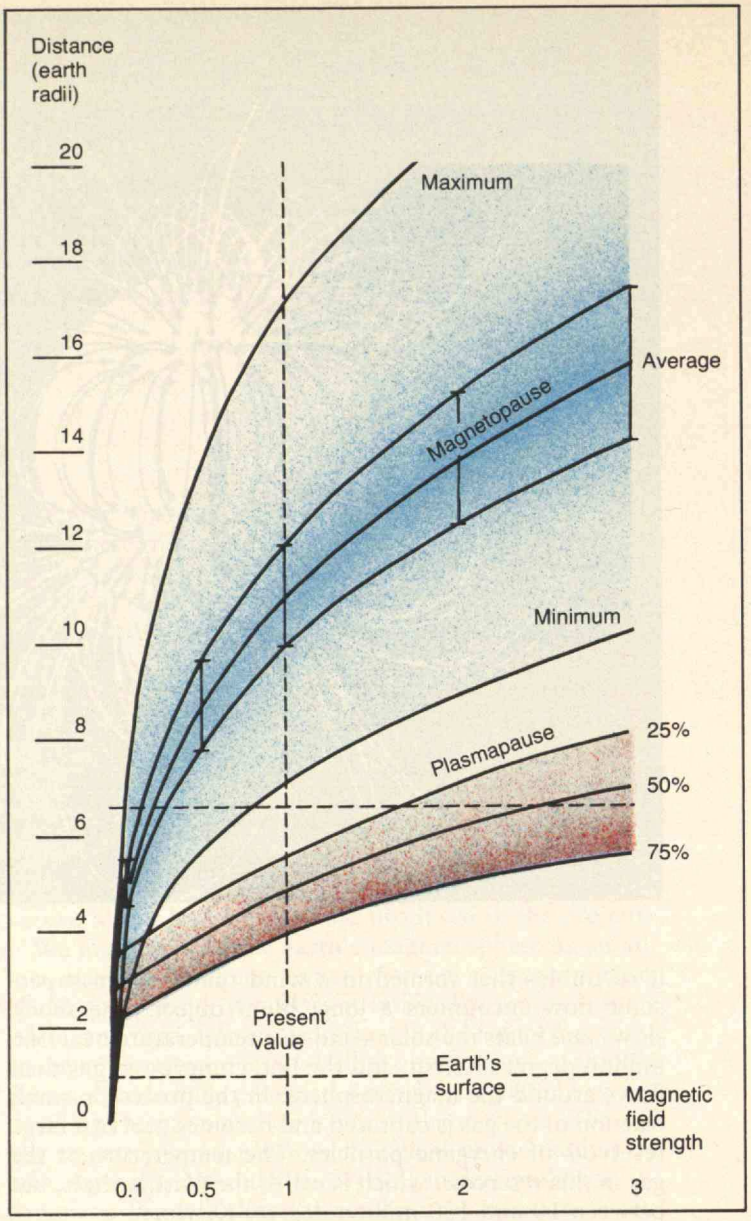
enough to allow calculation of the plasmapause position given only the solar wind's flow speed and magnetic field. Thus both the polar and equatorial borders to our planet's auroral zones can be predicted for an arbitrary strength of its dipole, the first from the outer boundaries of the plasma sheet and the second from the position of the plasmapause. Another useful quantity to know is the amount of energy coming into the magnetosphere from the solar wind; the more energy, the more spectacular the auroral display. This energy also derives from the frictional coupling, and therefore depends on the speed and magnetic field of the solar wind.

The Paleomagnetosphere

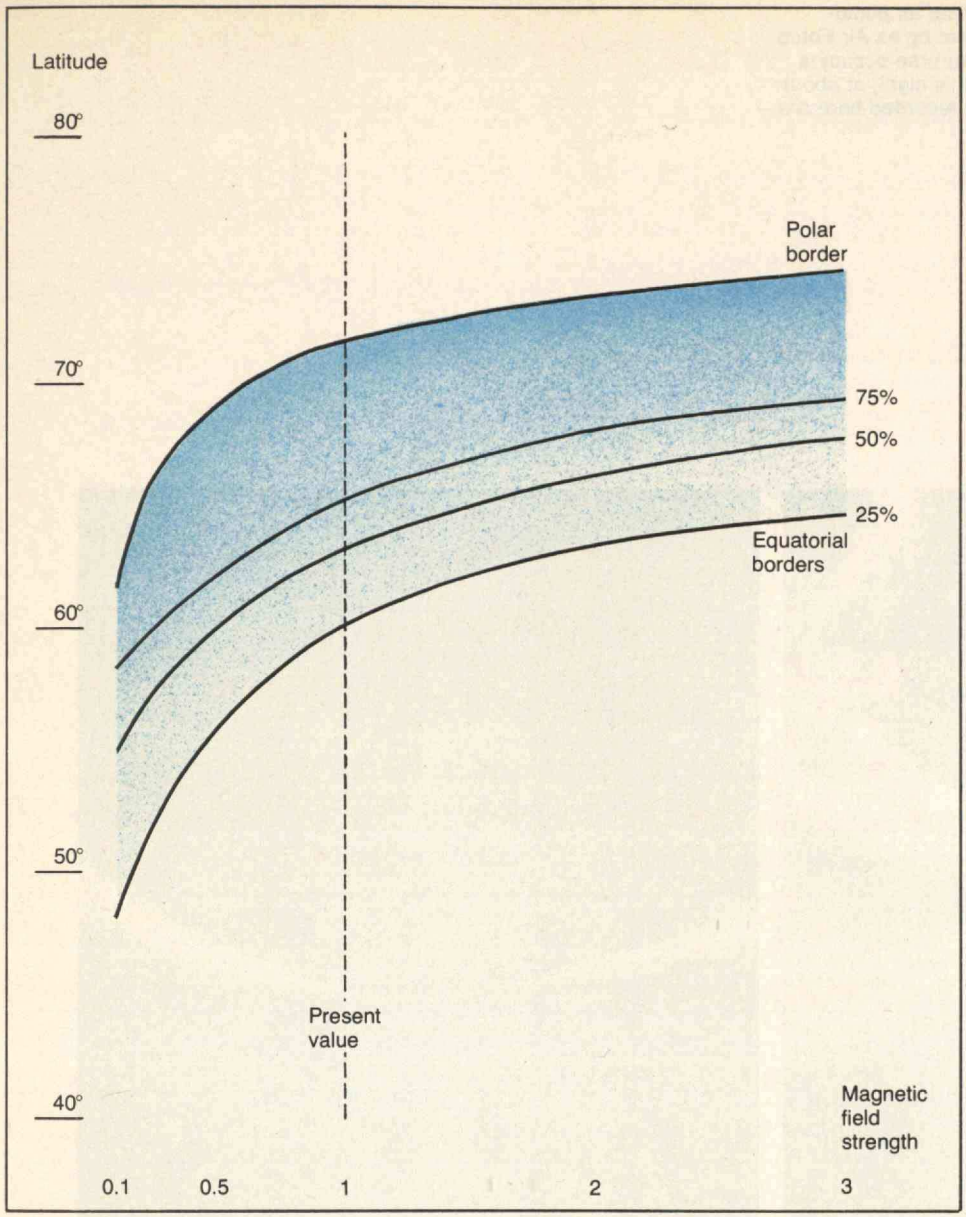
Our brief look at the structure and workings of the magnetosphere shows that the latitudinal bands within which the aurora appears depend on the strength of the earth's dipole, and hence are subject to long-term variations as the dipole strength varies. But, as described earlier, there are also the much shorter variations caused by disturbances of the solar wind — disturbances characterized by high wind speeds and intense, turbulent magnetic fields, which guarantee strong coupling to the magnetosphere and consequent magnetic and auroral storms. It is now possible to determine and compare the ranges of variation due to long-term, earth-generated and short-term, sun-generated causes. The long-term part has already been mentioned; it can be extracted from the record of fossil magnetism. To represent the short-term part, statistics on the solar wind from 1966 through 1969 have been compiled. Available data from other years since 1961 indicate that the chosen period is representative of the rest.

The results, shown on page 29, can be summarized as follows. In response to solar-wind variations, the magnetopause may vary in position by as much as 10 per cent of its average, and the plasmapause by 25 per cent of its average. On rare occasions, 50-per-cent excursions from the average position occur in the magnetopause distance, and even larger percentage excursions in the plasmapause distance (the latter are not shown in the figure). Over far longer periods of time, the sizes of the magnetosphere and plasmasphere increase and decrease with the strength of the dipole moment. For dipole strengths between two and three times the present value, the plasmapause frequently extends beyond the distance (6.6 earth radii) at which the centrifugal and gravitational forces cancel on a body that co-rotates with the earth. Beyond this distance, a co-rotating mass such as a charged particle in the plasmasphere would escape unless restrained by something other than gravity. In the case of the plasmasphere, the restraining force is provided by the earth's magnetic field, whose lines of force are stretched like rubber bands to provide the restraining force against the outward sling of the plasma. If the dipole strength increases sufficiently, the stretching of the magnetic field produces a disc-shaped distortion in the equatorial plane, where the centrifugal force is strongest. An extreme distortion of this type was discovered at the planet Jupiter by the Pioneer 10 and 11 spacecraft, and has been dubbed a "magnetodisc." In the direction of smaller dipole strengths, the average size of the magnetosphere shrinks. The plasmasphere also shrinks, but more slowly, such that for a dipole strength at approximately two per cent of the present value the plasmasphere on average fills the magnetosphere.

These facts have implications for auroral phenomena. The range of frequent auroral occurrence moves poleward for increasing dipole strengths and equatorward for decreasing strengths. Further, during times of significant magnetic disturbance, the latitudinal width of the auroral regions is greater for small dipole strengths. A calculation shows that at the latitude of Boston, aurorae would be present more than a quarter of the time (that is, on more than 91 nights of the year) when the dipole strength is a tenth of its present value. Aurorae are now observable in Boston on an average of five nights per year.



Aurorae, then, are more frequent and geographically more widespread when the earth's dipole is weak. At the low end of observed dipole strengths, the auroral zones occupy a latitudinal band through all of Europe. Moreover, the low end of the range can be associated with field reversals during which the magnetic poles move equatorward, bringing the auroral zones to even lower latitudes. In the middle of such a reversal, the non-dipolar field dominates, but the subject of non-dipolar magnetospheres is as yet unexplored. Still, the present non-dipolar field is probably representative of such a situation. A picture of the magnetic field lines from the earth with the dipole component removed shows a complicated pattern asymmetric both in latitude and longitude. Since the field



The movement of the plasmapause and magnetopause (left chart) and of the earth's auroral zones (right chart) as the strength of the earth's magnetic field changes. The plasmapause — the outer boundary for charged particles from the ionosphere — and the magnetopause — the outer boundary for interactions between the solar wind and the earth's magnetic field — both shrink toward earth when the planet's magnetic field diminishes in strength, and expand when the field strength increases. For a field strength somewhat more than double its present value, the plasmapause tends to lie beyond the so-called distance of synchronous orbit, at which any particle in gravitational orbit around the earth (for example, several weather and communication satellites) will remain motionless relative to the surface. When charged particles move beyond this distance, the earth's magnetic field is distorted into a disc-like shape similar to that recently discovered at the planet Jupiter. The changes displayed in the left chart produce changes in the auroral zones; as shown at the right, those zones move equatorward as the magnetic field strength diminishes. Such field shrinkage is associated with periods during which the polarity of the earth's dipole flips. It did so in Paleolithic times, and the chart accordingly suggests that Stone Age man in European latitudes witnessed frequent auroral displays.

is in general weak and the pattern contains many poles (while the dipolar field, of course, contains only two) the total area over which particles gain access to the atmosphere should be quite large, and regular auroral displays over most of the earth seem guaranteed.

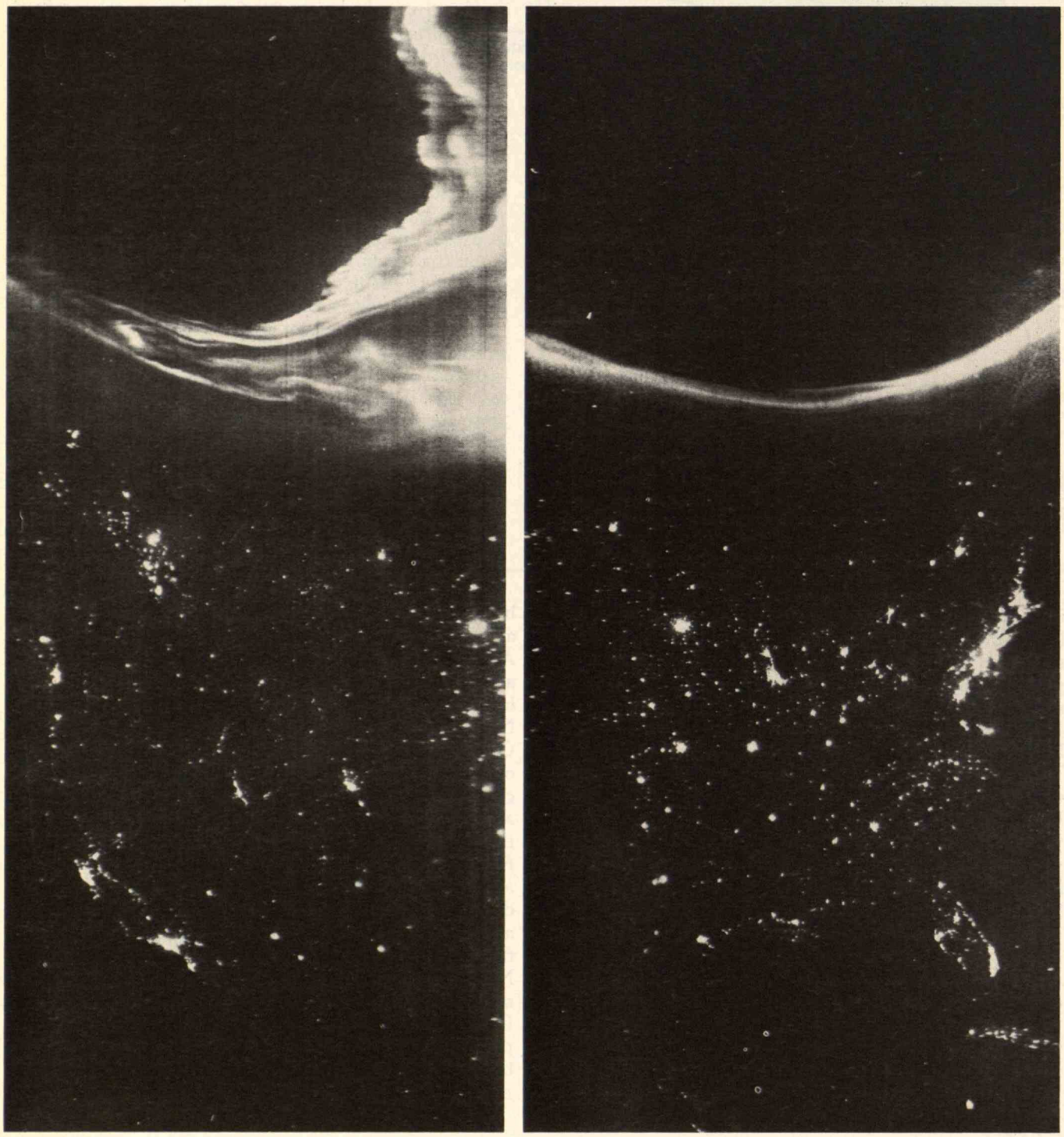
Implications for Archeology

The Laschamp and Lake Mungo events occurred somewhere in the intervals designated by archeologists as Upper Paleolithic — that is, between 10,000 and 30,000 years ago. This period coincides very nearly with the time when cave-wall paintings and sculpted figurines were being produced by Cro-Magnon man in France and Spain. Abundant artifacts from this era exist, many as yet uninterpreted. The possibility that any of these represent Ice Age impressions of the aurora from the time when aurorae made nightly displays in these regions should be considered.

Some insight into the forms that auroral representations might take comes from the study of folk traditions among the natives of arctic regions, to which the northern lights have largely been confined in historic times. There is a fortunate coincidence here in that Eskimo cultures bear similarities to what is known of Stone Age cultures, and lines of direct cultural descent have been suggested. Arctic traditions regarding the aurora are remarkably alike: rather than being omens, as they are in mid-latitudes, aurorae are the spirits of people who have died. Not all spirits flicker in the heavens: for the Eskimos of Canada and the Hudson Bay area, aurorae are the spirits of those who have died a voluntary or a violent death. For certain Indians of the northern Pacific coastal area, and also for certain Siberian Eskimos, the aurora borealis is the home of those who die a violent death. The Lapps of Finland and northern Russia speak of the aurora borealis as "the dead in battle" and as "the spirits of the murdered." These beliefs are helped by the lower borders of aurorae frequently being red, suggesting bloodshed; but they are relieved by a belief from the western coast of Norway, where the aurora is said to be "the unmarried maidens dancing." It is their way of existence after death. In most of these traditions, aurorae are the spirits of people who distinguished themselves in some way that was beneficial to their group. For one's spirit to join the aurora is generally considered an honor.

The contemporary supersitions from auroral regions

Aurorae over western and eastern North America, as photographed from an altitude of about 830 kilometers by an Air Force satellite on midnight of January 5, 1973. The aurorae occupy a latitude band with an equatorward border, on this night, at about 60° N. Also visible in the infrared wavelengths recorded here are population centers in the United States.



suggest reasons why Stone Age man might have made artifacts depicting auroral forms. If the frequent occurrence of aurorae gives rise to traditions in which spirits are embodied in auroral forms, then depictions of aurorae can play the role of spirit totems in religious, magical, or other cultural rituals. Physically durable symbols of aurorae could guarantee the recipient distinction after death. Post-mortem rituals for the same purpose are possible. The use of artistic representations of aurorae is obvious for sympathetic magic, in which the artist believes that he gains control over the object depicted.

Where might examples of such representations be? They could be present but unrecognized in the known artifacts. Among the possibilities are the serpentine meanders or "macaronis" found on rocks, in habitation sites, and on cave walls from Cro-Magnon times. These seemingly meaningless doodles resemble nothing we normally associate with Stone Age existence, and they have gone uninterpreted. The most dramatic of them are found on a ceiling deep in the cave of Rouffignac in France. Here lines drawn in red clay by the fingers of many different people resemble the folded-curtain patterns of aurorae. Perhaps geology and space physics will have an offspring in the field of archeology.

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George L. Siscoe is Professor of Meteorology at the University of California at Los Angeles; he recently completed a two-year leave of absence at M.I.T.'s Center for Space Research, where this article was written. Dr. Siscoe received his S.B. and Ph.D., both in physics, from M.I.T. He now conducts research on atmospheric electricity, the upper atmosphere, and the solar wind and its interaction with the magnetic fields of earth and the other planets. He has been associated with many of M.I.T.'s spacecraft-borne experiments that measured the plasma in interplanetary space and in the vicinity of the planets.

Daniel Brand
Massachusetts Executive Office of
Transportation and Construction, and
Associate Professor, Harvard University

Bringing Logic to Urban Transportation Innovation

Urban transportation is in a state of crisis, with air pollution, traffic jams, and huge transit deficits only a few of the symptoms. We must find ways to significantly lower the cost of urban travel both to users and society, and there are no easy off-the-shelf ways to do this.

In this article I hope to show how to respond sensibly to these problems, by presenting logical *performance specifications* for future transportation systems. While I certainly don't suggest that we stop work on current transportation projects, we must see the definite shortcomings to some "easy technological fixes" that have been suggested. Such fixes may not meet the demand for urban transportation, return their financial and social investment, or even be sound technology. I hope to show where this is the case.

Transportation in the U.S. today is a "big ticket" item. Total transportation expenditures have claimed almost 20 per cent of the total G.N.P. for the last decade, and urban transportation accounts for just under half of this expenditure. Obviously, innovation in such a substantial area of the economy will have far-reaching consequences.

Until recently, most government action in urban transportation has been in response to real or perceived changes in the market demand for each transportation subsystem. The government has limited itself to aiding growth, as in the case of the private automobile-highway system, or attempting to stimulate growth, as in the case of urban public transportation. But yesterday's logic no longer matches today's national concerns. Operators of private vehicles do not pay the real costs, to individuals and the country, of the energy shortage and air-quality degradation that they help incur.

Government programs to aid both public and private transportation are now in serious trouble. New urban expressways have been blocked by controversy in almost every major city. As deficits for urban mass transit systems skyrocket, the public and their administrators are quickly realizing that only higher fares or controls on private auto use, and not more miles of track, will lower these deficits.

There are signs of improvement in the urban mass transit situation. The "energy crisis" may change the traditional low public opinion of the value of urban transit. And in the near future, the necessity to restrict use of private vehicles may increase public appreciation of public transportation even further, and create a politically acceptable climate to raise transit fares. (Tax credits to lower-income transit riders would help resolve the inequities caused by higher transit fares.) New transit riders, reluctantly diverted from private autos because of energy use restrictions, could add enough revenue to make up the remaining transit deficits.

But as promising as such transit scenarios seem, they are only conjecture and, more importantly, do not direct themselves to the *primary* function of urban transportation, and *how well* that function is being served today.

Illustration courtesy of Pullman Inc., Chicago, Ill.

The City and Transportation

The function of city transportation is to overcome urban space, and the function of cities, in turn, is to reduce the need for transportation. As long as transportation costs are less than the benefits, transportation helps cities to maintain the economic and social interdependence which distinguishes them from more isolated rural areas.

Over the last half-century, the perceived cost of transportation to urban consumers has declined, and cities have spread out, resulting in increases in space and privacy for most urban residents and increased land availability for more efficient horizontal manufacturing processes. Cities are definitely in what William Garrison of the University of California at Berkeley calls the third stage of innovation as regards the private car:

The first stage of innovation typically occurs when an invention performs an existing function better than before. The early motor car was faster and pulled more weight (on dry roads) than the horse. But its function was the same as that of the horse. In the second stage of innovation, the invention is improved and new uses are found for it. In the motor car's case self-starters were developed, vehicles were adapted to move goods as well as people, and chauffeurs were added to create the urban motor bus. In the third stage of innovation the structure of the surrounding system — in this case, the city — adapts so that the innovation can perform at still lower cost and increasing gain to individuals.

Cities have been changing rapidly to meet the motor car's needs. In U.S. cities, the private automobile is responsible for about 95 per cent of all person-trips. The structure of our cities has changed to allow the automobile to operate more effectively — with more dispersed residential patterns, longer and less dense travel corridors, and cheaper land for wider streets being only a few examples. But such changes also mean that fixed-route and schedule transit services operate less effectively! The spoke-like transit routes radiating out of

We must develop automated guideways carrying dual-mode vehicles at fraction-second spacing if we are to improve urban transportation significantly.

the city no longer serve the bulk of travel patterns in today's cities, when citizens desire easy access throughout the urban grid.

The very success of the automobile has created problems which lead to much of the use of other forms of transportation. The central business districts (CBDs) of major cities are now the overwhelming market for transit. In the CBD "overconsumption" of the auto has led to high parking fees and traffic congestion. Private vehicle users pay these costs to gain "free" movement; and CBD-bound travelers avoid them by using public transit. Still other travelers — the poor, the elderly, the young, and the handicapped — have no access to a car for either CBD or non-CBD trips, and must also be served by urban transit.

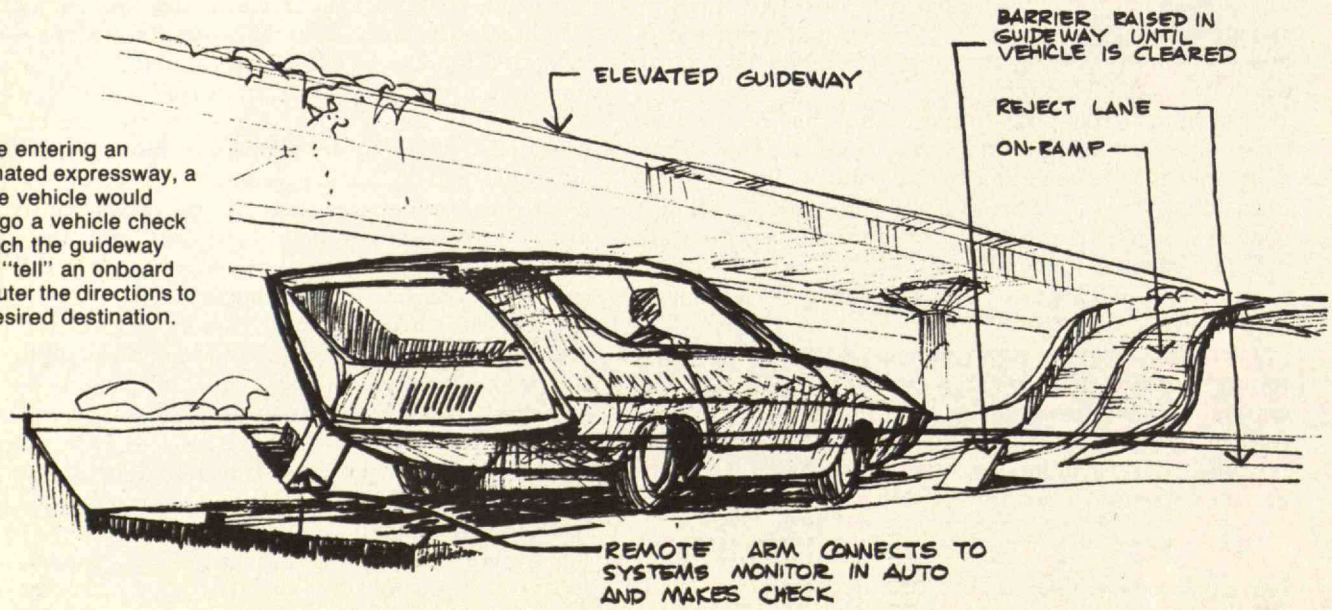
Social Costs Must Be Lowered

To some, logical urban transportation improvements don't solve just mobility problems; they solve urban development problems. But since most people admit lack of agreement on urban development goals, there is obviously going to be great uncertainty underlying recommendations for urban transportation based on such goals. One alternative, therefore, is to proceed incrementally to attack little transportation bottlenecks without an overall plan — essentially the situation today in our cities. Or, planners can examine the criteria governing current urban transportation decisions to see if any system, existing or potential, can lower both travel costs and social costs of urban transportation.

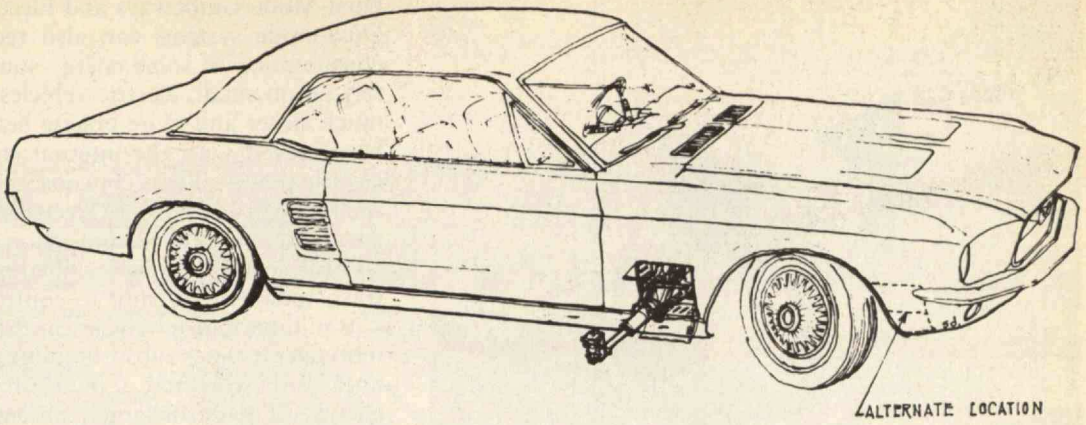
Unquestionably, any logical future urban transport system must lower the social costs of urban transportation drastically. Highway builders, accustomed to building through open land, made the major mistake of ignoring such costs in the cities. Their urban expressways have become stalled in controversy over such "indirect" costs as residential and business disruption, and air and noise pollution. The urban highway system appears to have reached the limit of its physical capacity. At considerable expense, some increases in network capacity can be obtained by better utilizing existing networks by mandatory routing. However, capacity increases from such systems will be limited compared to those that might have been available from new expressways.

Government Must Not Compound Problems

The government's response to such pressures is to reduce the use of motor vehicles, but in ways that may work against the cities' traditional function of reducing the need for travel. The same government which, until recently, aided growth in private car travel, now, under the Clean Air Amendments of 1970, wants to reduce passenger-car mileage in some urban areas substantially



Before entering an automated expressway, a private vehicle would undergo a vehicle check in which the guideway could "tell" an onboard computer the directions to the desired destination.



A dual-mode version of the Ford Mustang, developed by Professor Dwight Baumann of Carnegie-Mellon University, now runs along a test track near the university campus. Guidance on the automated guideway is accomplished by means of the arm shown behind the front wheel. (All drawings by Scott Danielson, from *Project Metran Report,* M.I.T. Press, 1966).

by 1977. They assume that public transit and car-pooling will take the place of drive-alone auto travel in these areas, leaving the economic activity at either end of the trip unaffected.

Unfortunately, travel behavior is more complex. People change their travel decisions, not only in what mode they use, but also in the dimensions of *where* they go and *how often.* For some important types of trips, our preliminary evidence indicates travelers are far more likely to choose another destination than another mode of travel, when entry into certain areas of cities is restricted or made more expensive. Thus, proposals to reduce the 95 per cent of urban travel now served by private cars may cause serious distortions and diseconomies which only compound the original problem.

The Environmental Protection Agency, under pressure from Congress, has recently dropped most disincentive plans for private auto travel in built-up areas, and substituted only mild incentives for ride-sharing. While this has lessened the danger of counterproductive government action, the original problems with our urban transportation systems remain.

The Traveler Must be Understood

Because our cities are so far into the third stage of innovation, a logical, innovative transportation system capable of serving them must recognize the components of the present travel market and how the market is being served. I have noted that the first stage of innovation is successfully achieved when an invention improves the performance of a function. And the great bulk of urban transportation is now performed, flexibly in time and space, by the private car.

You might assume that some public agency could provide urban transportation services more cheaply than could individuals, and still earn a profit. This would be true if transit could collect enough people in space and time to make user fees more than cover the cost of the service. If individuals' travel needs overlapped completely, the fixed-route, fixed-schedule service of present urban mass transit could serve as a perfect link between all origins and destinations at the times when such trips were desired. Mass transit would then not have its severe underconsumption problem.

Unfortunately, fixed-route, fixed-schedule transit doesn't overlap all origins and destinations in time and space of present urban travel. For example, in 1963, only about 6 per cent of all trips in the greater Boston region were made on its relatively well-developed rail transit system, and this market share has declined still further since then.

The 6 per cent or fewer riders who find it advantageous to use rail transit in Boston spend only about 40 per cent of their total travel time in the rail transit vehicle, and 60 per cent getting to and from the rail transit stations. Research has shown that these "access activities" are about two to three times as noxious to travelers per time unit as line-haul riding time. This means that on a weighted basis, about three-quarters of a rail transit rider's perceived travel time is spent getting to and from his primary mode of travel. But for auto travel, which accounted for about 83 per cent of Boston-area trips in 1963, only about 10 per cent of travel time is spent in access. Therefore, new transportation systems, if they are not to become functionally obsolete before they begin service, must reduce walks and waits.

Such statistics illustrate the very great disparity between public and private urban transportation service. To hurdle the first stage of innovation in transportation, planners must first understand how users view the system. They must concern themselves with what influences consumer behavior if improvements are to reduce the cost of urban travel.

But the consumer point of view is not the only concern. There is also a legitimate public point of view dictated by logic (and sanity) in designing new transportation facilities. To reduce the symptoms of the urban transportation problem which our unmatched private mobility brings — space consumption, air pollution, and energy costs — we can and must specify performance and technological requirements for transportation innovation which lower each of these social costs of transportation. And these requirements must lead to a transportation system which is a logical and compatible collection of components or subsystems. The task is not difficult.

The Logic of Dual-Mode Transportation

To reduce the space needed for transportation, both the physically and the socially perceived size of urban transportation facilities must be reduced. This means reducing the *time* spacings between moving vehicles, as well as their space consumption when stopped. Reducing time spacings requires automating the driver function — with vehicles under automated operation at short headways (time spacings between vehicles) on automated guideways. However, we will always be limited by economics in automating the line-haul portion of trips, just as we are limited today for economic reasons in the mileage of

The German automated "Cabinentaxi" system has also achieved headways of under one second, traveling at 22.5 miles per hour. The system contains two types of vehicles, those which travel over and those which hang beneath special tracks. The system is currently being tested on a five-vehicle, 0.6-mile track in Hagen, Germany, and a longer track, with more cars is planned near Erlangen. (Photo courtesy of DEMAG Fördertechnik and Messerchmitt-Bölkow-Blohm)

planned expressways. Automation of driving will always be limited to those congested areas where it is necessary to reduce travel costs, including social costs. The easiest way to provide the door-to-door transportation service enjoyed today for the bulk of our urban trips will still be to rely on manually-driven vehicles.

Thus, we have derived the primary specification of the logical urban transportation innovation, that it be *dual mode transportation.* Dual-mode systems combine automated guideway and non-guideway systems, using the same vehicle or passenger "pod" for both. By combining automated guideway operation and manual operation on local streets, such a system could give the door-to-door service enjoyed by most travelers, within the current metropolitan structure.

Dual-Mode Guideways and Electric Power

Dual-mode systems can also reduce air pollution and consumption of some energy sources in short supply by relying on small, electric vehicles. Electric power allows much closer and more precise headway control than can be achieved with the internal combustion engine. And electric power allows conversion of basic energy sources, such as hydrocarbons, to electrical energy at a few remote sites, where improved conversion efficiency and pollution control devices can be installed and maintained. In contrast, today we attempt to control pollutants from over 120 million motor vehicles in the U.S. Electrical energy, moreover, creates substitutability of basic energy sources, and can introduce a flexibility into transportation energy-use patterns largely absent since the 1920s.

Once they leave the electrically-powered automated guideways, vehicles might have flexibility in their on-board energy source. Probably, though, two motors per vehicle would not be economical, and vehicles off the guideway would be powered by batteries, rechargeable on the guideways.

How Much Speed, How Much Guideway?

For urban planning purposes, the automated portions of dual-mode systems can be thought of as automated expressways carrying small vehicles at 60 miles per hour. About twice as many miles of "automated expressways" as conventional expressways will be needed according to preliminary studies of demand. Additional mileage equal to existing grade-separated transit lines will also be needed. Since congestion-free guideways will stimulate travel, we have allowed for increased demand in these estimates. But these higher mileage requirements will not mean greater intrusion on urban space.

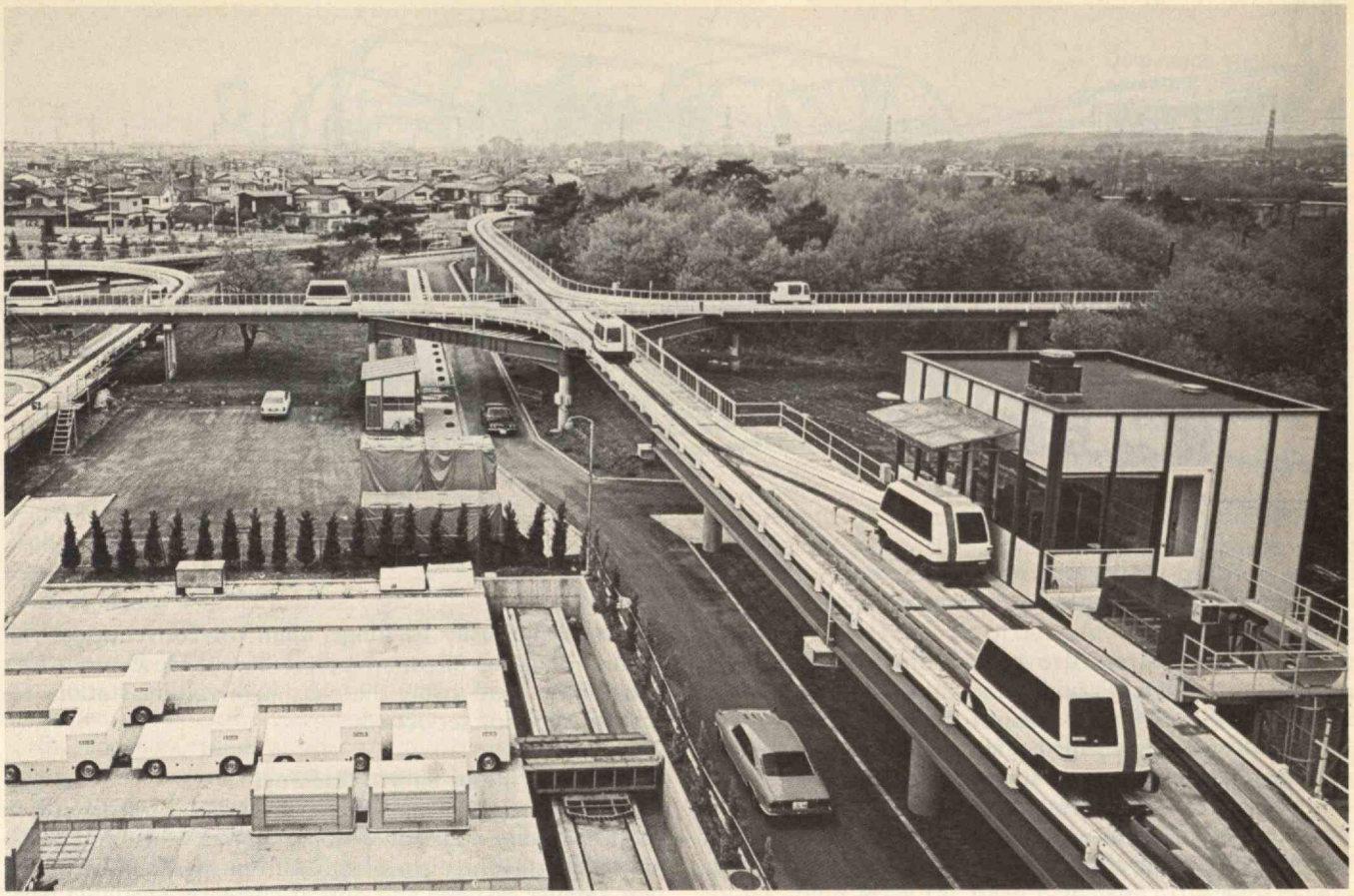
In contrast to huge urban expressways, the size of automated guideways should be manageable. Instead of eight, 12-foot lanes plus shoulders, medians, drainage areas, etc. cutting a 200- to 300-foot swath across your favorite city, there would be two, six-foot-wide lanes. Such a narrow cross-section could be completely enclosed, sound-proofed, buried, or put through buildings to minimize dislocation and disruption.

Fraction-Second Headways Needed

To equal an eight-lane expressway's capacity, a two-lane guideway would have to carry four times as many vehicles per hour. Since freeway vehicles maintain two-second minimum average headways between cars at freeway capacity, guideway vehicles will have to achieve half-second headways. Achieving safe, reliable, fraction-second headways is thus the major technological barrier to overcome in developing a transportation system to reduce urban travel costs.

We can achieve fraction-second headway operation of small vehicles on automated guideways today, but the problem is to design such systems for day-to-day operating conditions. These systems must be far safer than today's urban automobile highways, because to users any accident will reflect upon the entire guideway system.

Experimental work in West Germany and Japan indicates that the technological problems are not insurmountable. Vehicles may be controlled electronically, have mechanical fail-safe linkages, or have systems that maintain such short spacings between vehicles that shock-absorbing bumpers could cushion any collisions, which would be at low relative velocities.



Although dual-mode automated transit systems are still at the drawing-board stages, significant advances are being made in single-mode, automated personal rapid transit. The most advanced such system in the world today is the Japanese CVS (Computer-controlled Vehicle System). Currently being tested on a relatively complex, three-mile test track near Tokyo, the CVS system is capable of automatically moving people and cargo at headways under a second. The 60 vehicles now being tested on the system can travel up to 50 miles per hour. Cargo vehicles are shown at the left of the photo. (Photo courtesy of the Japan Society for the Promotion of Machine Industry)

Concern for Transit: PRT

The fraction-second headway requirement for significant urban transportation innovation results not only from the requirement of serving the majority of existing urban travel. It is also necessary if an innovative urban transit system is to be buildable.

To overcome the fixed-route, fixed-schedule limitations of present transit, technologists have developed a concept known as personal rapid transit (PRT). This most important emerging technology in urban transit today attempts to overcome limitations of present transit by offering small-vehicle, non-stop operation available instantly, on an automated network, with off-line stations. Three major differences in concept between "pure" PRT and conventional transit are:

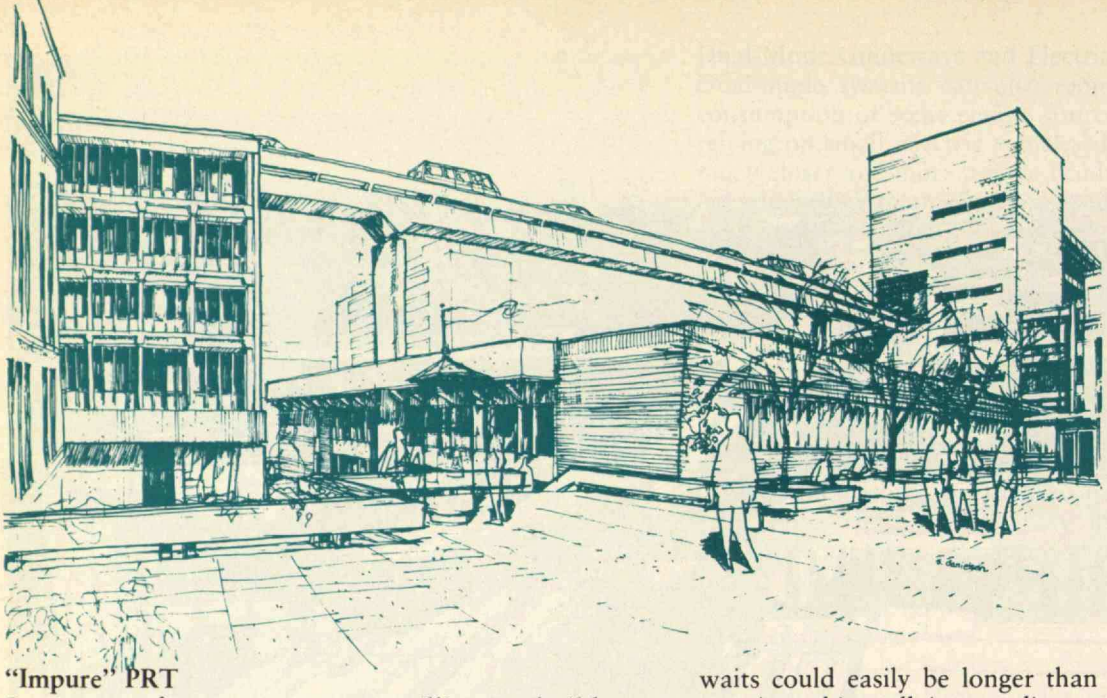
— PRT's off-line stations mean that the PRT vehicles need not wait for stopped vehicles at intermediate or on-line stations — PRT is a "flow" system.

— PRT stations can be close together since not all vehicles must stop. This gives better coverage of an area than conventional transit, at additional expense for the additional stations, of course.

— Small, personalized vehicles would be available at all times at each station, theoretically meaning no waiting and seating available to all comers.

Thus PRT in concept offers considerable service improvement over conventional transit. However, the requirement of having a vehicle ready to board on demand for a trip means that the vehicle will have a very low average occupancy. "Pure" PRT planning studies — based on no data — estimate an average occupancy of about 1.5 persons per vehicle. Assuming such an occupancy in a system required to carry 10,000 people per hour — the upper range of so-called intermediate capacity transit, and a long-held minimum volume for conventional rail rapid transit — a PRT system would need a spacing of .54 seconds per vehicle (3,600 seconds/hr. × 1.5 passengers/vehicle × 1 hr./10,000 passengers). This calculation assumes, as do serious plans for PRT systems, that very few alternative paths are available in the guideway network.

Again we see the requirement for headways of approximately a half-second, but as a requirement for innovative transit, and not just in relation to highway capacity! In reality, the 1.5-passenger-per-vehicle estimate may be high, for in a large PRT network, the probability seems very low of a person entering a station at the same time as another person going to the same distant station. And, with a lower occupancy, a still closer spacing is needed to achieve the requisite high capacity.



Because of their low weight and low noise levels, high-capacity, electric guideways could be built over pedestrian malls and through buildings.

"Impure" PRT

Some manufacturers are now willing to build PRT automated guideways with headways of about ten seconds for 30- to 50-mile-an-hour systems. At this speed, ten seconds is the so-called safe stopping time, or "brick wall headway," assuming a safe emergency deceleration rate of 0.2 g. So, if present systems are not yet capable of operating at fraction-second headways, the only way to increase passenger throughput in PRT systems is to increase vehicle occupancy.

At the current ten-second headway, a vehicle occupancy of 28 passengers per vehicle is required to achieve 10,000 passengers per hour throughput (10,000 passengers/hour × 10 seconds/vehicle × 1 hour/3600 seconds). This means PRT vehicles will have to be held at a station until many passengers going to another station or stations board; or, passengers will have to be picked up at several stations. Holding a vehicle at one station to accumulate passengers means longer waits for passengers. While shorter waits can be obtained for the same vehicle occupancy by stopping at more stations, this strategy decreases average speeds and makes the operation more closely resemble conventional transit.

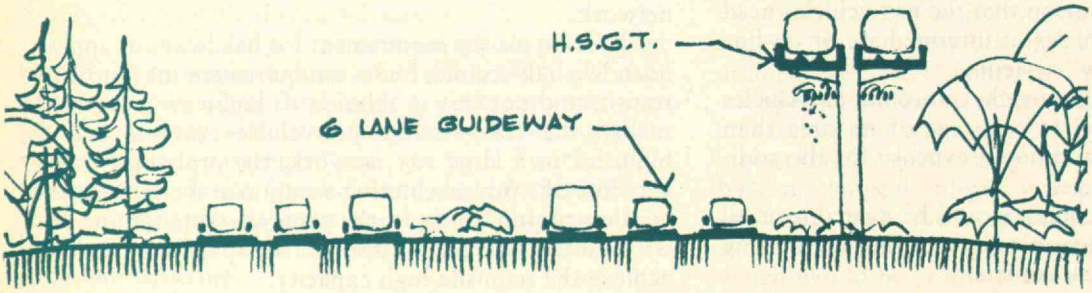
As a result of these restrictions, the generally proposed operating plan for PRT is a compromise strategy. This plan — "impure" PRT, or Group Rapid Transit (GRT) — entails stops at each of a set of adjacent stations to pick up passengers, and then express runs to a destination group of stations. The run is regularly scheduled, ideally with relatively short waiting times of one to three minutes. However, there are problems. For large systems, so many destinations must be served that capacity restrictions would increase initial waits. In fact, these initial waits could easily be longer than for conventional rail transit making all intermediate stops. However, GRT's flexibility could insure that very high volume stations received superior service.

No PRT Without Short Headways

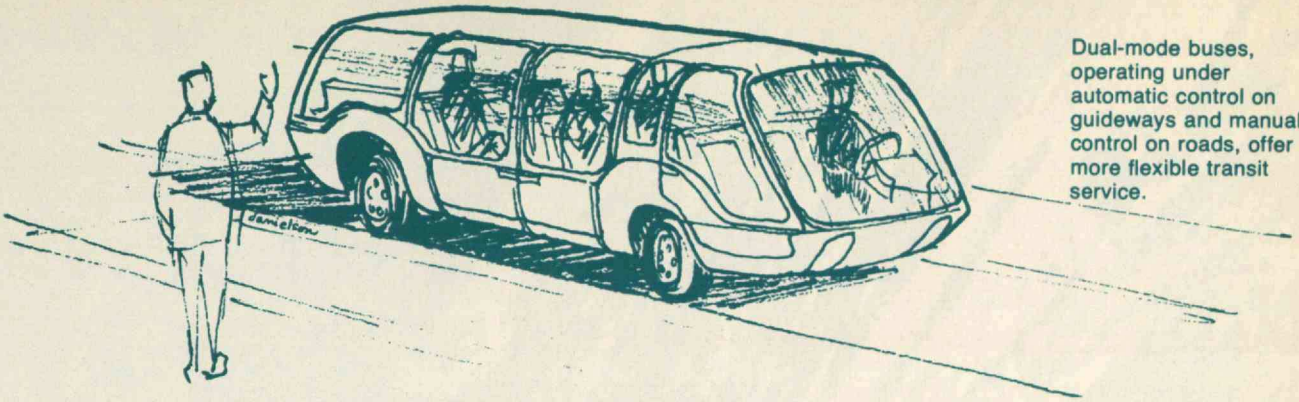
The advantages of GRT over conventional transit are, in concept, somewhat fewer stops, shorter waits, and possibly higher average travel speeds; but these apply mainly for smaller systems and only if currently available technologies are "pushed." However, PRT, pure or impure, can be superior to conventional transit in guideway coverage, at additional expense, of course. This means that walking time to and from the guideways can be less than that with conventional rail systems.

PRT planning reports seem to abound in which guideway networks are so dense and coverage so great that they might be mistaken for the local street system of a small city. We must then ask ourselves why PRT or GRT guideway systems should be any cheaper to build per mile than conventional rail transit networks. We must also ask where the per-mile savings are for PRT over conventional transit. There are no savings evident in command and control systems. There may be savings in power distribution systems, with individual rather than trains of vehicles, and thus smaller surges of power when vehicles accelerate. However, there will be more vehicles and thus probably higher costs in the vehicle subsystem. Right-of-way costs may be less, but only if the guideway cross-section is much slimmer and easier to locate on existing publicly-owned rights-of-way than conventional rail transit.

The real cost savings over conventional transit are al-



A high-capacity automated guideway built along an existing expressway corridor would save land for landscaping or for construction of other transit modes such as a high-speed ground transportation system.



Dual-mode buses, operating under automatic control on guideways and manual control on roads, offer more flexible transit service.

leged to be in the structure. This is most likely true for light two-to-six-passenger vehicles. But for the 28-passenger vehicles required now without fraction-second headways, neither the vehicle weight per foot of length — on which guideway design in part depends — nor the vehicle cross-sections are much less than for conventional transit vehicles. And PRT tunnels will be equally as expensive as rapid-transit tunnels.

In summary, there appear to be no substantial cost savings over conventional elevated trains or subways with existing PRT — or GRT — technology. Indeed, a small- or medium-sized city can now buy, almost off the shelf, a group rapid transit system with off-line stations and comparable, but potentially superior, service for about the same direct and social cost as a conventional rapid transit system of the same length. That is, a city can buy such a system if it doesn't mind the start-up problems that appear to be plaguing the PRT systems in Morgantown, W. Va., and the Dallas-Fort Worth Airport. In any case, the service given by GRT is essentially transit service; it doesn't overlap well in time and space with more than a small fraction of total urban travel. Thus, ridership and revenue from such a GRT system is not apt to make the financial picture of this relatively easy technological fix any different from that of conventional transit systems.

True personal rapid transit means personalized vehicle service and fraction-second headways. Without fraction-second headways, passengers must be assembled to boost line-haul capacity, service is degraded, and per-mile system costs are increased. Thus, significant improvement in urban transit service in general also requires very-short-headway systems. Fraction-second headways are the only way to lighten transit vehicles and reduce structure size and costs — both direct costs *and* the social costs of large guideway structures and, similarly, urban highways.

Dual-Mode and the Future

George Pastor, Associate Administrator of the Urban Mass Transportation Administration, has pointed out that the ability to automate transportation safely and efficiently is a central issue in this and most other efforts to increase productivity in commercial or military systems. But automation is economical in our transportation system only if we can achieve very large jumps in system productivity to allow the costs of built-in redundancies and down-time which characterize the most successful uses of computers today. Achieving safe and reliable fraction-second-headway operation, therefore, is the central technological problem on which this country should be focusing its urban transportation innovation efforts.

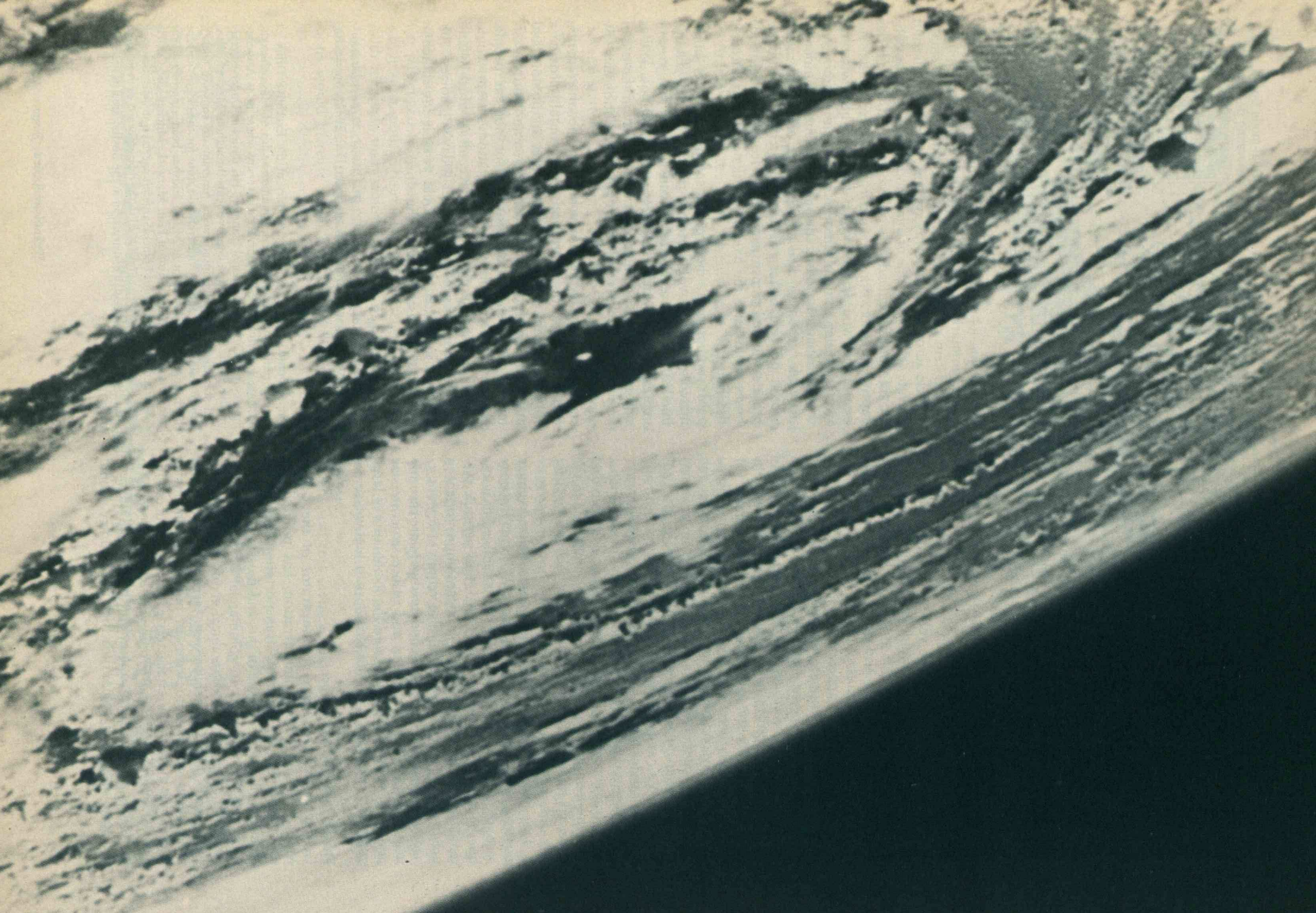
To summarize, the logical innovative urban transportation system consists of fraction-second headway, small-vehicle automated guideway systems, carrying public and private vehicles capable of dual-mode operation. For public transportation, riders would be carried on vehicles captive to a network as transit is today, except that the new service would be service on demand. The new service would overlap in time, if not in space, with many urban travel demands. Adding the more extensive guideway network needed for dual-mode private vehicle operation would provide better coverage of a city than today's grade-separated transit networks. Moreover, dual-mode buses could leave the fixed networks to further increase flexibility.

Most important, the fraction-second headway automated guideways would provide the high-quality reliable line-haul express service for private vehicles that present expressways provide under the best of conditions. And as said before, electric power allows flexibility in the use of basic energy sources and control of air pollution at a few sources.

A word may be necessary here on the oft-recurring argument that a transportation system should provide a "choice". Many people argue that cars are noxious and many don't own or can't drive them, so an "entirely different" mode should be provided for non-car people. However, an integrative transportation system would provide for several classes of service, all of which would be substantial improvements over today's "choices". Indeed, an integrated system should provide for choice in the most optimistic sense of the word.

Suggested Reading:
Proceedings of a Conference on Dual-Mode Transportation. Transportation Research Board, Washington, D.C. 20418. Special Report No. 166. In press.

Daniel Brand is currently Undersecretary of the Executive Office of Transportation and Construction, Commonwealth of Massachusetts, on leave from his duties at Harvard University where he is Associate Professor of City and Regional Planning. His duties as Undersecretary involve public transportation improvements throughout Massachusetts, and state responses on transportation programs to conserve energy, improve air quality and provide transportation for the elderly and the handicapped. He has taught at M.I.T. and has been a partner in the transportation consulting firm of Peat, Marwick, Mitchell and Co. He was a member of Governor Francis Sargent's special transportation task force (1969-1970) which contributed to the then-unheard-of decision to abandon plans for freeway construction in the Boston area, in favor of mass transit.



Hurd C. Willett
Professor of Meteorology, Emeritus
M.I.T.

The Sun as a Maker of Weather and Climate

Is worldwide climate today undergoing significant change, or is it merely fluctuating randomly around a long-term norm calculated on the basis of perhaps a century or more?

The question was first suggested by the strong warming trend observed throughout the world between 1920 and 1940. Gilbert N. Plass of Texas A and M University in 1956 probably originated and certainly best articulated the theory that an increase of atmospheric carbon dioxide produced by the combustion of fossil fuels could best explain this warming. His theory stimulated considerable popular concern and a scientific debate which has yet to be resolved. This paper presents an alternative explanation, proposing that variations in solar activity best fit recent observed climatic fluctuations, and offering a very sketchy physical hypothesis. On the basis of these observations are ventured some climatic predictions for the next century.

We begin with definitions: climatic fluctuations are described in terms of fluctuations in the pattern of general atmospheric circulation, notably the westerlies of the middle latitudes and the subtropical easterlies. General circulation patterns are designated as being strongly or weakly zonal (that is, concentrated and strong or dispersed and weak, relative to the normal); they are designated as being at high or low latitudes as the pattern is displaced poleward or equatorward of the seasonal normal. The patterns are further designated as being strongly or weakly meridional, depending upon the intensity of the north-south winds which exchange polar and tropical air masses. Weak zonal and strong meridional circulation tend to occur together to constitute climatic stress. Such stress is marked by strong longitudinal contrasts of temperature and precipitation and by strong seasonal contrasts between maritime and continental air — hence by extreme contrasts between continental summer and winter temperature.

The processes which result in earth's weather — and in the longer range its climate — are both complex and subtle. The author describes his speculations on the effect of one variable — the cyclical magnetic activity of the sun which results in the sunspot and secular cycles which are familiar to solar scientists. "The solar-climatic hypothesis best fits the observed climatic changes of the past 700 years," writes Dr. Willett, and by extrapolating these correlations into the future he concludes that, "barring an interruption of predictable solar cycles, the next ice age is unlikely for at least 10,000 years . . ." (Photo: N.O.A.A.)

Forty Years of Warming Weather

The sequence of recent weather patterns on earth may be characterized as follows: the substantial warming trend that began about 1920 peaked in the higher middle latitudes during the 1930s, in the lower middle latitudes in the early 1950s and in subtropical latitudes in the late 1950s or perhaps as late as the early 1970s. A substantial cooling trend began in the polar and higher middle latitudes in the 1940s, in the lower middle latitudes in the late 1950s, and in the subtropical latitudes even later — perhaps only now. In general, the lowest temperatures in the middle latitudes occurred in the early and middle 1960s, followed by a slight warming trend in the late 1960s and early 1970s.

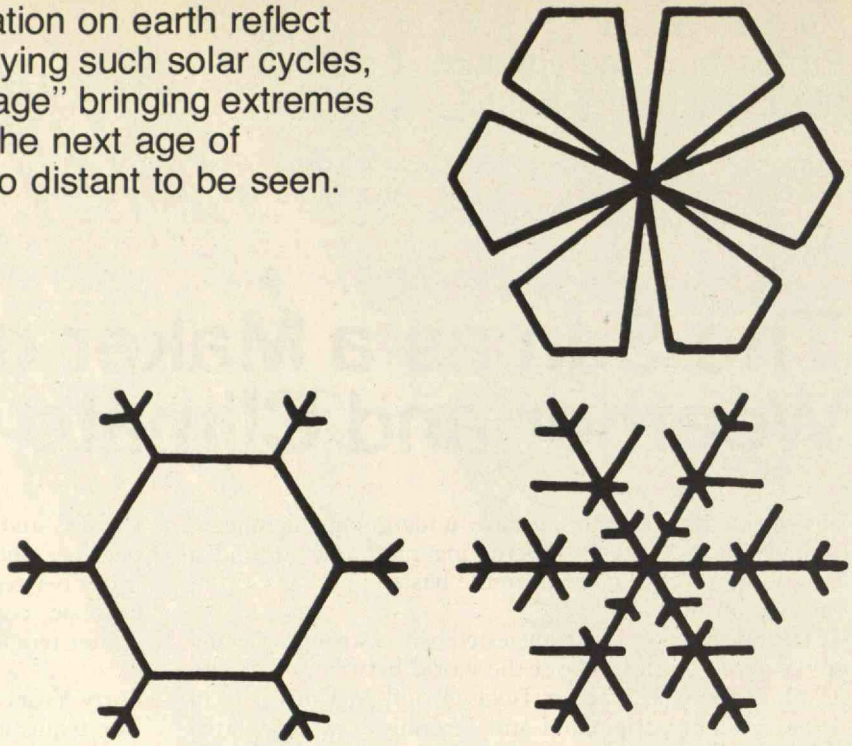
Geographical patterns of precipitation departures are more local and of much smaller scale, depending on topography and moisture sources, than are those of temperature departures. Though comprehensive data are therefore largely unavailable, the following summarizes our understanding of recent rainfall variations:

The warm decade of the 1930s brought the most severe droughts of the century to many regions of the middle latitudes, notably the dust bowl in our western plains; severe Russian droughts triggered liquidation of the Kulaks, and there were severe droughts in southern Australia and in other mid-continental — as opposed to east coastal — parts of the world. The 1940s brought generous rains to the drought regions of the 1930s, though there was a tendency to substantial deficiencies in east coastal regions.

The early- to mid-1950s, like the 1930s, were a markedly dry period in the marginal interior continental regions, notably the American southwestern plains; severe drought was restricted to latitudes equatorward of 40°, and east coastal areas were normally or abnormally wet. Like the 1940s, the 1960s provided generous rainfall to the marginal interior continental regions of middle latitudes, but there were record dry years in many east coastal regions. The 1960s and early 1970s brought severe drought to the middle and lower subtropics, notably in southern Asia and central Africa.

To date the 1970s have witnessed only a very slight tendency to drought in middle latitudes — and that only

Patterns of atmospheric circulation on earth reflect cyclic changes in the sun. Studying such solar cycles, the author predicts a "little ice age" bringing extremes of cold by the year 2200. But the next age of widespread glaciation is still too distant to be seen.



in southern portions of the belt (our Mexican border states). Apparently there has been some dryness during the past two years in marginal Russian grain land, but the data necessary to put that occurrence into perspective are not readily available.

General circulation patterns during the past 50 years correlate with these temperature and rainfall records: strong high-latitude climatic stress patterns developed early in the 1930s. The 1940s were dominated by zonal westerlies at somewhat subnormal latitudes, and very strong climatic stresses marked the 1950s. Since then, the general circulation has been predominantly zonal, remarkably free of stress patterns.

Any prediction of future climatic change, including the possibility of a new ice age, must depend upon our understanding of these recent climatic fluctuations. At least two hypotheses are possible — one based primarily on man's pollution of the atmosphere, the other based wholly on natural variations of solar energy inputs. This paper will consider both and propose the latter as more consistent with data from the recent past.

The Atmospheric Pollution Hypothesis

During the past 50 years the outstanding trends of temperature are the sharp rise over much of the northern hemisphere, culminating in the higher latitudes about 1940, and the following cooling which reached its fullest in the higher and middle latitudes in the middle 1960s. If atmospheric pollution is hypothesized to explain changes of temperature at the earth's surface, it must especially help us to understand these trends.

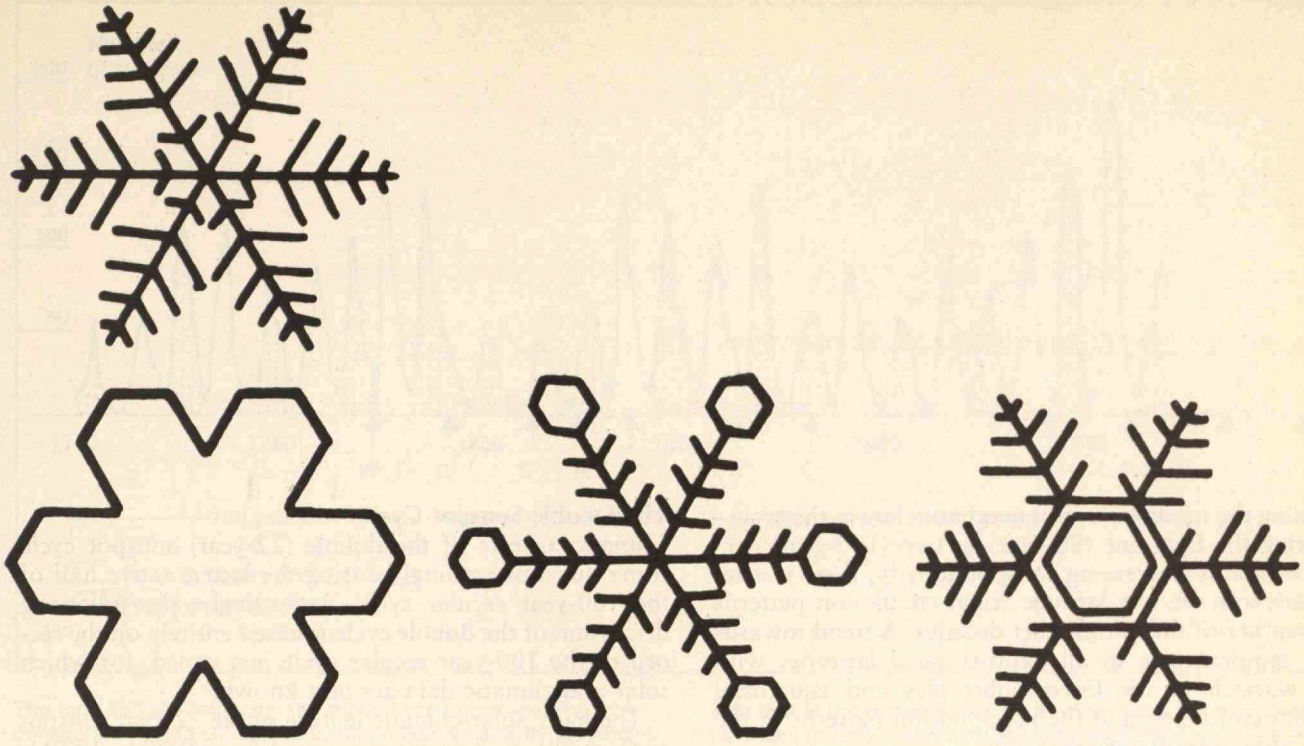
Since atmospheric carbon dioxide (CO^2) has continued to increase more than linearly throughout this period due primarily to the growing consumption of fossil fuels, Reid A. Bryson of the University of Wisconsin sensibly maintains that the hemispheric temperature should have continued to increase rapidly except as some other factor modified the effect of CO_2; he proposes that this factor is increasing dust and smoke in the atmosphere of volcanic or industrial origin.

Some analyses propose a different effect, suggesting that particulate matter in the atmosphere is much more absorptive of outgoing long-wave terrestrial radiation than of incoming short-wave solar radiation. This leads to a hypothesized "greenhouse effect" — more warming of the atmosphere in the high latitudes where outgoing terrestrial radiation exceeds incoming solar radiation than in the low latitudes, where the reverse is true; this "greenhouse effect" must tend to warm the atmosphere more at high latitudes than at low and thus weaken the general circulation and be counter-glacial in effect.

But if Professor Bryson is correct and the trends he projects continue as from 1940 to 1960 into the 21st century, the decrease of the mean temperature of the northern hemisphere must be expected to continue; this would lead, rather quickly and uniquely in the earth's history, to the advent of an ice-age climate and glacial conditions. It is this assumption that leads to pessimistic predictions of reduced food production and increased energy demand.

But the pollution hypothesis cannot properly be made to account for recent climatic fluctuations. Any estimate of the effects of atmospheric particulates is at best difficult to make and must be based on a number of assumptions; it is sensitive to the number, size, vertical distribution, and absorptive and radiative characteristics of the particulate matter, as well as to the wavelength and angle of all incident radiation. For this reason I believe it hopeless within the scope of present knowledge to reach a quantitative estimate of what particulate matter may be doing to the mean temperature of the hemisphere.

My own reading of the record convinces me that recent increases of atmospheric carbon dioxide have contributed much less than 5 per cent of the recent changes of atmospheric temperature and will contribute no more than that in the foreseeable future. If this is true, and the heating effect of CO_2 is considered negligible, then there is no need to invoke any cooling effect of particulate pollution to account for climatic fluctuations. Indeed, I believe that



man will pollute himself off the face of the earth long before he can pollute himself into an ice age.

The Solar-Climatic Hypothesis

Sunspot activity occurs in cycles which have been well studied and are widely recognized. Three of these cycles of solar activity are to be considered in relation to recent climatic fluctuations: the eleven-year sunspot cycle, the double sunspot cycle, and the longer secular cycle. Complete, quantitative explanations for the relationship between solar cycles and climate remain to be given, though some hypotheses can be suggested (*see page 50*) in the absence of the right kind of solar observational data and physical research. But a fair argument for the solar-climatic hypothesis of climatic fluctuation can be made, resting squarely on observed, historical relationships between solar and climatic cycles.

The Reversing Sunspot Cycles

The most widely recognized cycle of solar activity as it affects climate spans a period of about 22 years. The number of sunspots rises to a maximum, falls to a minimum, and returns to a maximum in an average of 11 years; but between each 11-year cycle there is a reversal in the direction of the sun's magnetic field. Thus each 11-year cycle has a polarity opposite to that of the preceding cycle, and conditions in fact repeat themselves only every 22 years.

The 11-year sunspot cycle (actually ranging from nine to 14 years) is of minor interest for climatic correlations; only in the equatorial belt is there any significant correlation between the 11-year cycle and the weather, notably temperature. At all higher latitudes the double (22-year) sunspot cycle completely obscures the single cycle in climatic significance, because alternate sunspot maxima have opposite effects on atmospheric circulation and weather. Accordingly, the following discussion takes no further account of the 11-year cycle except as the positive (major) or negative (minor) half of the 22-year cycle.

The Long Secular Solar-Climatic Cycle

The long solar-climatic cycle, based on both planetary configurations and sunspot and solar magnetic activity, is alternately of approximately 100 and 80 years' duration.

The following lists the broad features of the northern hemispheric (and probably also southern hemispheric) climatic patterns which tend to correlate with this long, secular cycle of solar activity:

The initial three or four quiet decades of each long cycle generally show strong zonal circulation patterns with maximum coldness in all except the equatorial and bordering subtropical latitudes, where low temperatures are probably delayed until the third and fourth decades; and wetness is likely in the middle, lower middle, and equatorial latitudes except in east coast continental areas in the middle latitudes. This climate of strong subtropical activity is favorable to glaciation.

The next two decades are marked by strong zonal circulation patterns shifting rapidly from low to high latitudes, temperatures rising to maximum in the polar and higher middle latitudes and to near normal in equatorial and subtropical latitudes, and increasing wetness poleward of 50° and in the subtropics. This is predominantly an interglacial climate.

For the 100-year cycles only, the three decades following high sunspot activity are a period of very active weather: high-latitude zonal circulation patterns break down sharply into climatic stress; extremes of temperature in the middle latitudes, with cooling first in the higher altitudes and some 15 years later in the lower-middle latitudes; and alternating drought and flood, first in the higher-middle and then in the lower-middle latitudes. It is a period of wetness, with many northeasters and hurricanes on continental east coasts.

Peak sunspot activity in the middle of the 80-year cycle is preceded in the middle latitudes by a sudden, brief rise of temperatures, then a quick return to low temperatures during and following the sunspot peak. There is a moderate upturn of temperature to a much lower peak

preceding the modest sunspot maximum late in the cycle.

During the final one (80-year) or two (100-year) decades of rapidly decreasing sunspot activity, there is a return towards the low-latitude zonal circulation patterns and weather of the initial quiet decades. A trend towards lower temperatures in all extra-tropical latitudes with peak warmth in the lower subtropics and equatorial latitudes continues, and the precipitation patterns of the initial quiet decades are repeated.

Two interesting facts stand out in the limited observational evidence relating temperatures to these secular solar-climatic cycles:

— By far the most significant temperature departures of the last secular cycle occur in the subtropics, where peak warmth of the warming trend occurs 20 years (or even more) later than it does at 50°N.

— The statistical significance of these temperature trends in the subtropics, and their clear tendency to follow the sun seasonally, suggest strongly that the secular cycles are caused by fluctuations in the effective radiation received from the sun.

Following the Cycles Through Flood and Drought

Precipitation trends are more complex and less well established than those of temperature, but a few broad correlations with prevailing circulation patterns of the last 100-year secular cycle may be noted:

The period of strongest low-latitude zonal circulation, from 1880 to 1910, was prevailingly wet across the United States in lower-middle latitudes (except on the east coast), and prevailingly dry across Canada in higher-middle latitudes; indeed, during the first two-thirds of this period western Canada experienced the most severe drought in its observational history, coincident with a very wet period across the southern United States. The only drought of consequence in the United States occurred in the Mexican border states in the 1890s.

Dry weather prevailed from 1910 to 1940 in the United States and southern Europe, and wet weather covered Canada and northern Europe.

The predominance of high-latitude zonal circulation ended during the early 1930s with the advent of strong weather systems in middle latitudes, and these persisted through the 1950s in lower-middle latitudes. The outstanding features of the 1935 to 1960 period as a whole are recurrent severe droughts in the midwest coincident with extreme wetness on the east coast (including northeasters in winter and spring and hurricanes in summer and autumn).

The Double Sunspot Cycle

Climatic aspects of the double (22-year) sunspot cycle come out more strongly during the latter, active half of the 100-year secular cycle. Accordingly, the following discussion of the double cycle is based entirely on the record of the 100-year secular cycle just ended, for which solar and climatic data are best known.

The basic solar-climatic feature of the 22-year sunspot cycle as observed during the period from 1870 to 1970 is a strongly contrasting change of the patterns of the general circulation during the period between one sunspot minimum and a following maximum with a *positive* solar magnetic field (Max^+), opposite in sense to that in the period between a sunspot minimum and a following maximum with a *negative* solar magnetic field (Max^-). Latitudinal changes of atmospheric pressure correlating with solar magnetic and sunspot cycles clearly indicate a tendency for the zonal circulation to weaken going into the positive half and to strengthen going into the negative half of the double sunspot cycle.

Strong weather patterns caused by polar highs in winter and by higher-latitude extensions of the lower-latitude oceanic high pressure cells in summer characterize the Max^+ phase of the double cycle. Absence of such patterns characterize the Max^- phases of the cycle.

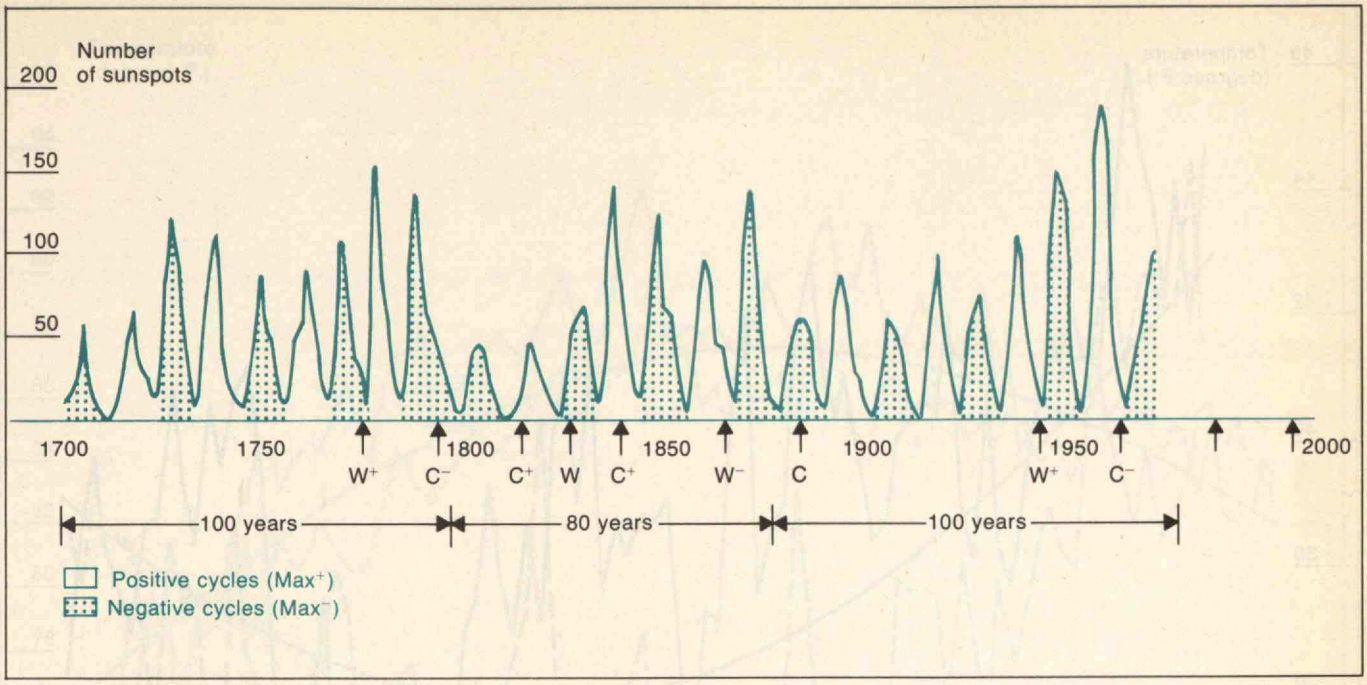
Solar Activity and Earth's Atmosphere

It is interesting to speculate on possible physical linkages between the solar and the climatic aspects of the secular and the double sunspot cycles. It was noted earlier that the temperature in subtropical latitudes during the summer season is the most significant manifestation of the secular cycles. This could result from either of two possible causes:

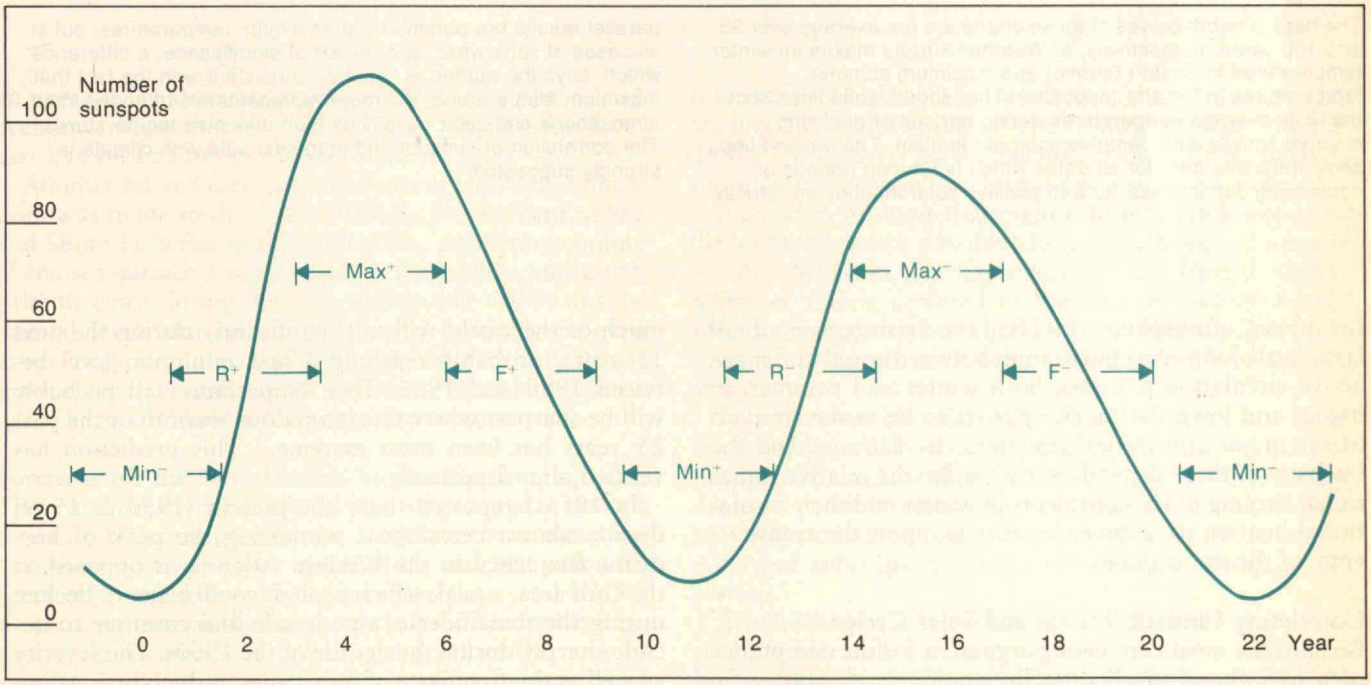
— A change in the direct heat of the sun (the solar constant).

— A change in the atmosphere of the earth to decrease its transmission of solar energy into the atmospheric systems; such a change might be caused either by a change in the photochemical equilibrium resulting in an increase in ozone or by the production of active condensation nuclei (cloudiness) in the upper atmosphere.

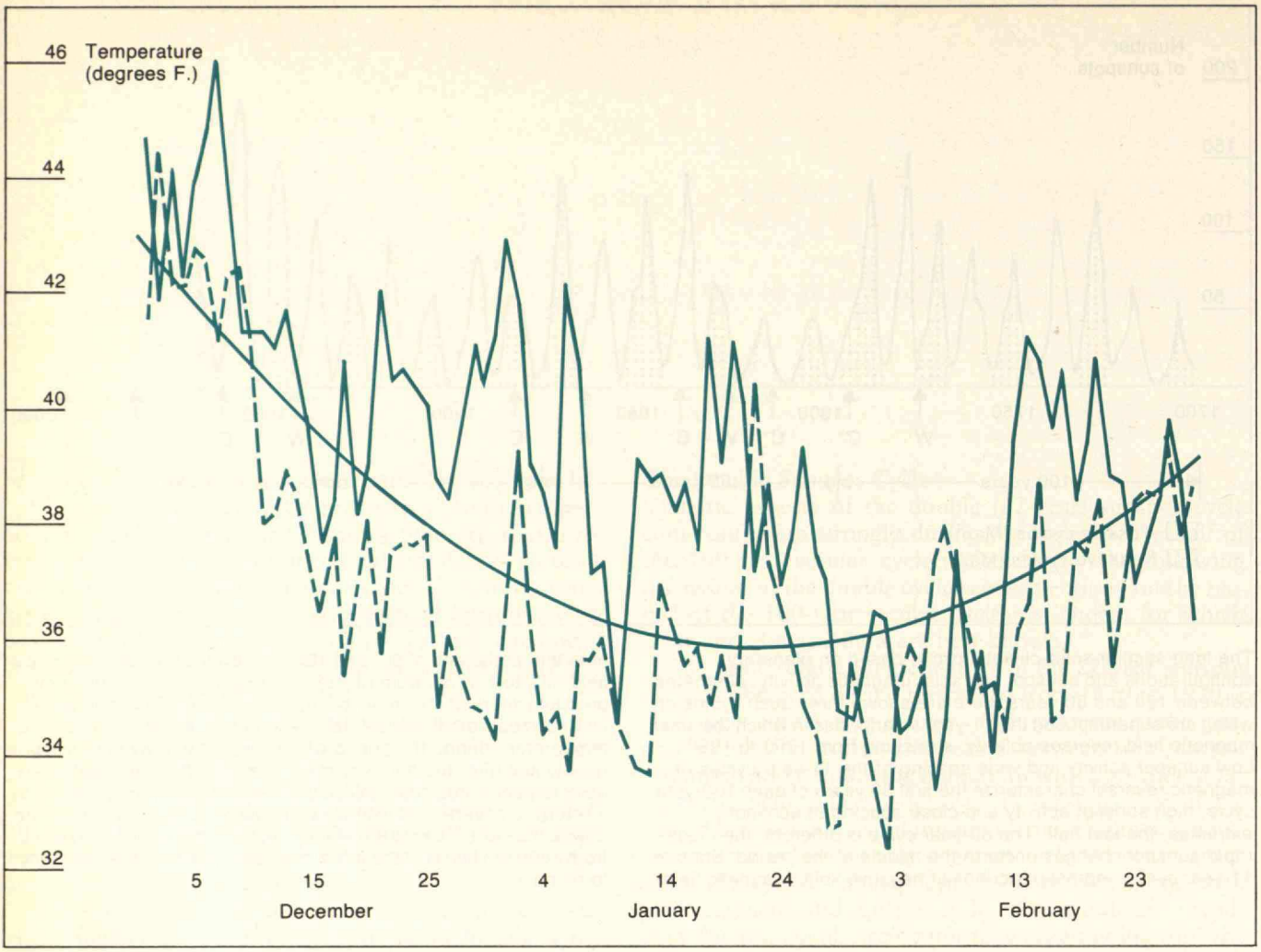
On the other hand, the most significant climatic manifestations of the double sunspot cycle are in the winter-season circulation in high latitudes, in the contrast between strong zonal circulation, and its breakdown into a climatic stress pattern. The one solar variable that meets this seasonal and latitudinal requirement is the solar wind, which could in turn affect the amount of ozone in



The long secular solar-climatic cycle, based on planetary configurations and sunspot and solar magnetic activity, alternates between 100 and 80 years; here are shown three such cycles on which are superimposed the 11-year solar cycles in which the solar magnetic field reverses polarity, stretching from 1700 to 1980. Low sunspot activity and wide spacing of the 11-year cycles of magnetic reversal characterize the first 30 years of each 100-year cycle; high sunspot activity and close spacing of sunspot extremes, the last half. The 80-year cycle is different: the most rapid sunspot changes occur in the middle of the period. Shaded 11-year cycles represent periods of negative solar magnetic field; note that at the end of 80- and 100-year cycles the solar magnetic field fails to reverse from negative to positive. The letters show probable years of maximum warm (W) and cold (C) temperatures, as analyzed from historical data. The author notes rapid rises of temperature during the period when sunspot activity is growing rapidly just after the half-way mark in each 100-year cycle. The peak temperatures came midway in the 80-year cycle, followed by a return to severe cold with falling sunspot activity. Since we are now at the start of a new 80-year cycle, says the author, the period from 1800 to 1880 is of the most immediate predictive significance to us now.



This chart shows the average of the five double sunspot cycles during the last 100-year secular cycle, with climatic experiences superimposed. In general, during these five cycles the climate became active while sunspots were at their minimum and growing rapidly — the positive half of the 11-year cycle — with solar magnetism changing from negative to positive (Min$^-$ through R$^+$); the weather was active, characterized by severe droughts in continental interiors. During the next nine-year period the active climate persisted but drought gave way to wetness and heat to cold. Then came six years (R$^-$ through Max$^-$) of more moderate weather, cool and wet. Finally, in six years from F$^-$ to Min$^-$, the zonal circulations shifted poleward and weakened, bringing warmer weather to northern latitudes. Clearly, thinks the author, these data established the connection of sunspot activity and solar magnetism with earth's climatic change.



The hard, smooth curves of these charts are the average over 93 and 100 years, respectively, of Weather Bureau maximum winter temperatures in Boston (above) and maximum summer temperatures in Omaha (opposite). The jagged, solid lines show the daily average temperatures during periods of declining sunspot activity with negative solar magnetism. The dashed lines show the same data for all dates which fell during periods of decreasing sunspot activity with positive solar magnetism. Strictly parallel results are obtained with minimum temperatures, but in all cases at somewhat lower levels of significance, a difference which, says the author, is "entirely consistent with the fact that maximum temperatures are more representative of undisturbed atmospheric and solar conditions than minimum temperatures." The correlation of sunspot and magnetic data with climate is strongly suggested.

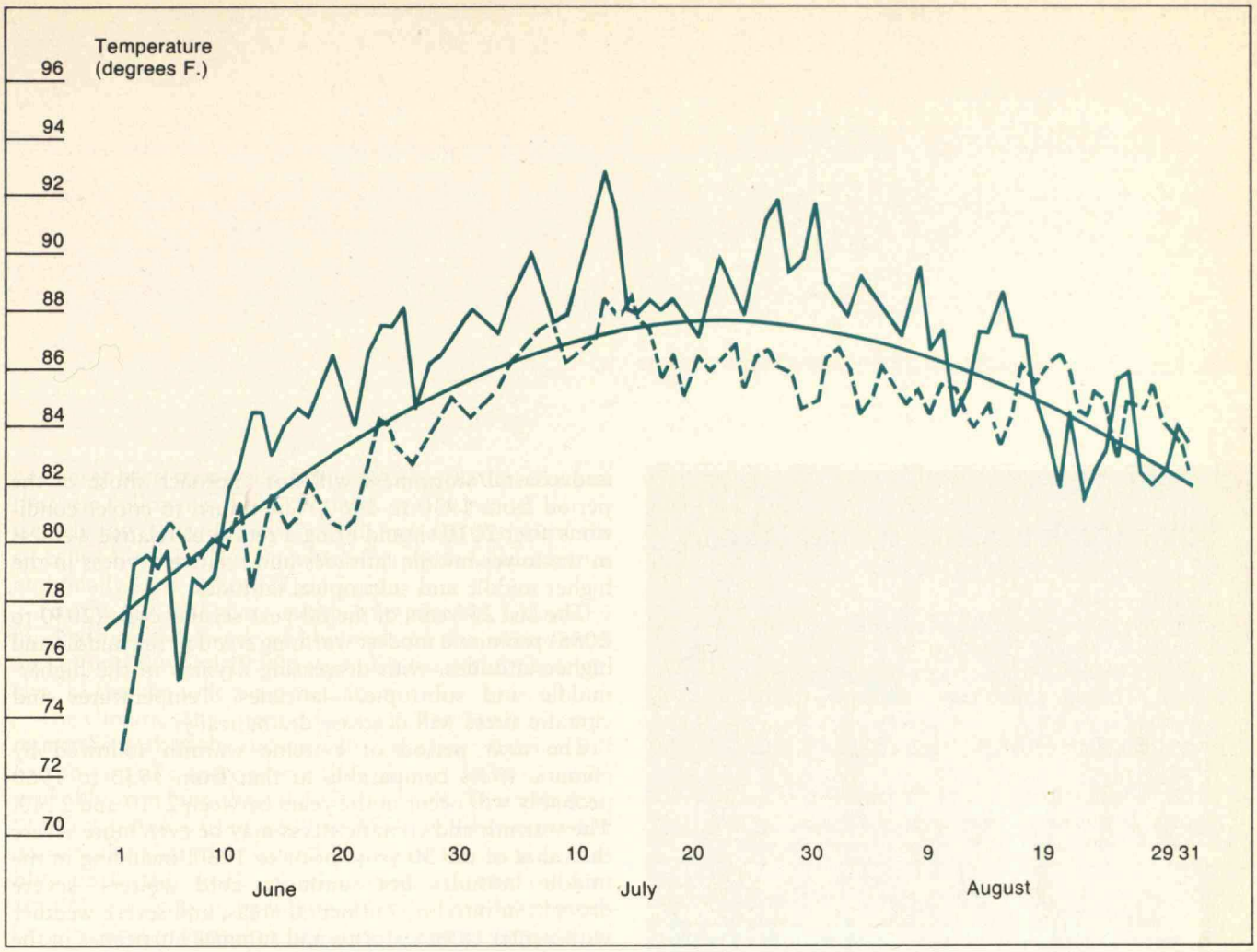
the upper atmosphere. In fact, the basic cause of all large-scale long-term fluctuation between zonal and more active circulation patterns, both winter and summer, in higher and lower latitudes, appears to lie in the strength of the major continental-maritime circulations. And the intensity of these depends in turn upon the relative radiational cooling of the continents in winter and their insolational heating in summer — that is, upon the transparency of the atmosphere.

Correlating Climatic Trends and Solar Cycles

Perhaps the most convincing argument for the acceptance of a hypothesis of climatic fluctuation is its success in prediction. The solar-climatic hypothesis has performed remarkably — indeed, without one serious error — in a number of long-term forecasts of climatic trend. These forecasts were all based on the approaching termination of one secular cycle and the lengthening of the double sunspot cycle with the advent of the new secular cycle.

In 1951 I proposed that "the temperature level over much of the world will fall significantly during the next 15 years, probably reaching a first minimum level between 1960 and 1965. This temperature fall probably will be sharpest where the anomalous warmth of the past 25 years has been most extreme." This prediction has verified almost perfectly.

In 1955 I reported that "the present (1950 to 1959) decade almost certainly is witnessing the peak of hurricane frequency in the Western Atlantic as opposed to the Gulf area, a peak which probably will begin to decline during the remainder of the decade and continue to decline sharply during the decade of the 1960s. The severity as well as the frequency of hurricanes in the North Atlantic coastal areas will decrease. At the same time there will be a slight, but not more than slight, increase in the frequency of West Gulf hurricanes, so that the total number of Atlantic zone hurricanes will decline, by the end of the 1960s, at least to the level of the period from 1900 to 1930. The period from 1960 to 1990 will probably find the overall frequency of Atlantic zone hurricanes at



an average level corresponding to 1870 to 1900, a level even lower than that of 1900 to 1930." To date this forecast has verified in every particular.

Another related forecast, which never received publication, was made to the State of Maine Department of Sea and Shore Fisheries in the mid-1950s, predicting cooling of the sea-surface temperatures of the middle and north Atlantic coast during the early and middle 1950s to subnormal levels during the 1960s and probably to even lower levels from the mid-1980s into the 1990s. By 1965, sea-surface temperatures off the Maine coast had fallen a full 5°F. to well below the long-term norm.

Forecasts for the Next Double Secular Cycle

These and other similar results give me courage to make a series of 180-year predictions, based on the assumption that the next two secular cycles of 80 and 100 years, respectively, will follow the solar chronology and related climatic pattern of the last two cycles. The double sunspot cycle is considered only in the detail of the next 30 years — and at that not with full certainty because of its imminent reversal of phase, its tendency to be less dominant during the first (relatively quiet) half of the long secular cycle, and our ignorance of its manifestations during the 19th century, when the last 80-year cycle should be analogous to the next 80 years.

In the next 25 years the temperatures in all latitudes will fall to significantly lower levels than those reached in the mid-1960s. Whether this decline starts immediately, leading to lowest levels in the 1980s, or starts in the 1980s with lowest levels reached in the 1990s, depends on whether the double sunspot cycle reverses phase.

No major, prolonged drought is foreseen in lower-middle latitudes except possibly along the subtropical margin — the Mexican border states of the United States. Whether this is centered in the first or second decade ahead also depends on whether the double sunspot cycle reverses phase. If it does not, the 1975-85 prediction stands.

In higher-middle and subtropical latitudes, the next two decades will be a predominantly dry period, particularly in Canada and northern Europe, with a severe drought possible across the Canadian plains. A similar ten-year period of severe drought is likely in southern Asia and subtropical Africa, but decadal timing is uncertain.

From 2000 to 2010 A.D., there will be an abrupt return to markedly warmer weather in the middle and higher latitudes, followed rather quickly by a return of temperatures to the low levels predicted for the next two decades. The warmth of the 2000-2010 decade will not approach that of the period from 1930 to 1960. The warm decade will tend to be wetter in higher-middle and in subtropical latitudes and thus will terminate the prospective drought conditions there. It will be drier in the lower-middle latitudes, but stress conditions of drought

Solar Cycles: Cold Winter Ahead

Beware.

Drawing on his research and experience correlating cycles of solar activity with weather and climate on earth, Hurd C. Willett, Professor of Meteorlogy Emeritus at M.I.T., thinks an abnormally cold winter with heavier-than-usual snowfall awaits the eastern U.S. It's a forecast with a "moderate confidence rating," he says — likely but not certain.

For the nation east of the Continental Divide, said Professor Willett in early November, "the current prolonged period of very warm weather should terminate before the end of November, to be followed by a prolonged spell of very cold weather, probably most severe during the mid-winter month of January, to give us a winter season markedly colder than normal.

"A moderating trend should set in late in the winter, followed by a comparatively mild early spring.

"Rather frequent rapidly eastward-moving active storms should result in above normal precipitation generally except in the far southwest, along the west Gulf Coast, and along the Canadian border.

"This storm activity, combined with a winter much colder than last, should result in snowfall and snow accumulation generally heavier than normal, and heavier than last winter, in most of the eastern part of the country except from the northern plains eastward across the upper Great Lakes into northernmost New England, where precipitation will be less than last year.

"Snowfall probably will be less, and melting earlier, than last year going into the spring season."

Although Professor Willett's forecast last year of a very cold winter was in error, his companion prediction of a heavy snow season across most of the northern half of the country was accurate. In addition, both the early fall (September-October) and spring (March and particularly April) were colder than usual.

Professor Willett said the same general conditions as last year — combining a strong westerly circulation with alternating periods of extreme warm and cold — are continuing in full force this year, as it should be at this phase of the double sunspot cycle.

He considers it likely that the same pattern of alternating extreme warm and cold periods will continue in the months ahead. However, their timing has been running out of phase with last year — the autumn has been very warm, in contrast to a year ago — and this heightens the chance of a cold winter and warm spring this year, he says. — *J.M.*

and coastal storminess will not approach those of the period from 1930 to 1960. The return to cooler conditions after 2010 should bring a return to relative wetness in the lower-middle latitudes and relative dryness in the higher middle and subtropical latitudes.

The last 25 years of the 80-year secular cycle (2030 to 2055) promise a modest warming trend in the middle and higher latitudes, with decreasing dryness in the higher-middle and subtropical latitudes. Temperatures and climatic stress will decrease dramatically.

The next period of extreme warmth followed by climatic stress comparable to that from 1930 to 1960 probably will occur in the years between 2110 and 2140. The warmth and climatic stress may be even more severe than that of the 30 years prior to 1960, including in the middle latitudes hot summers, cold winters, severe drought in interior continental areas, and severe weather with winter coastal storms and summer hurricanes in the United States and northern Europe.

Predictions Beyond 180 Years

If the next ice age is in fact foreseeable, it can come only after the year 2150. The following predictions bearing on its possible advent are based entirely on solar-climatic analogy with the past, disregarding, as in earlier conclusions, any possible human or volcanic pollution of the atmosphere.

Only two cycles are utilized in this discussion. The first is a 10,000- to 12,000-year cycle, for which no supporting solar information is available; rather, it is supported by geological evidence of two or three peaks of glaciation during each of the last two glacial periods; this cycle evidently passed through its extreme interglacial phase about 5,000 years ago and probably is approaching its extreme glacial phase. The other is a cycle of approximately 720 years (4 × 180 years) which has strong solar support.

There occurred in each of the 12th and 14th centuries a 25-year period of severe climatic stress. The first stress period terminated all communications between the Norse Vikings and their Greenland and Iceland colonies; the second one — the most severe period of climatic stress on record, most extreme between 1370 and 1390 — ravaged all of northern Europe with strong blizzards and extreme cold in winter (including record storm flooding of the Dutch lowlands) and heat and drought in summer. The consequences in famine and plague reduced the population of the British Isles by two-thirds. Old Chinese records indicate that this was a period of sunspot activity such as

has never been seen since. European observations suggest that the following three centuries was a period of extremely low sunspot activity. This was the period of the so-called Little Ice Age, in which there was rapid advance and finally slow retreat of glaciation.

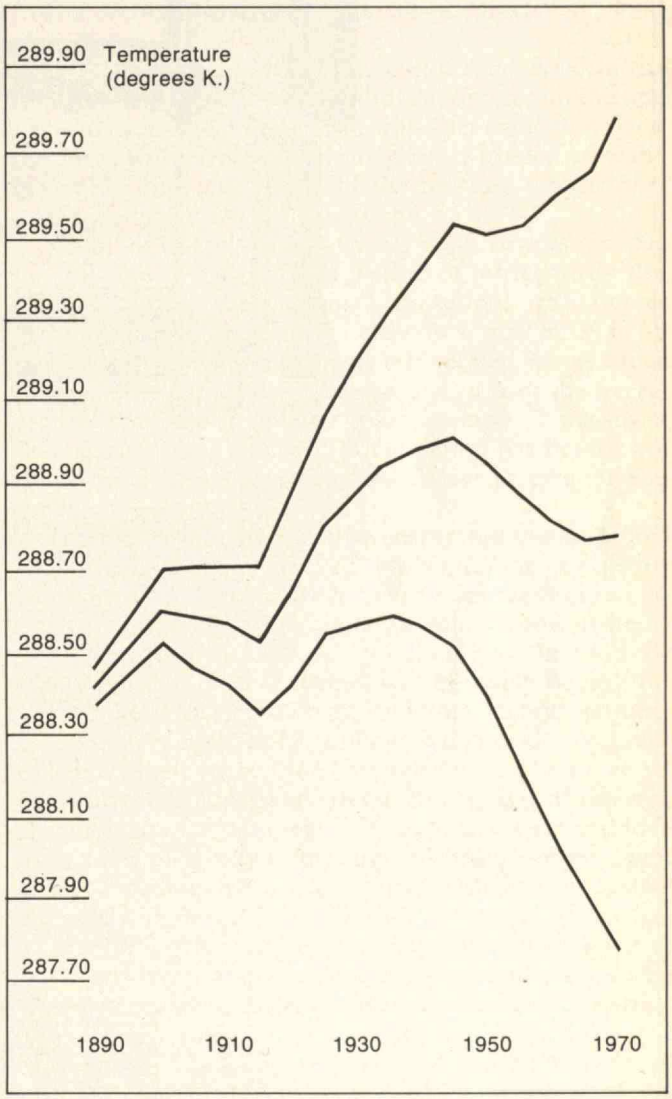
For the last 300 years, sunspot activity has followed a marked upward trend; on the basis of this observation and of the 700- and 10,000-year climatic and sunspot cycles, I offer the following predictions:

The climatic stress period from 2110 to 2140 will represent the peak of the current 720-year cycle; weather will be substantially more severe than that of 1930 to 1960, probably matching that of 1370 to 1400. The following "Little Ice Age," from 2200 to 2550, will be somewhat more severe than that from 1500 to 1850. It will probably mark the peak of glaciation of the current 10,000-year cycle, to be followed for the next 5,000 years by a cyclical progression towards a warmer interglacial period of the long cycle.

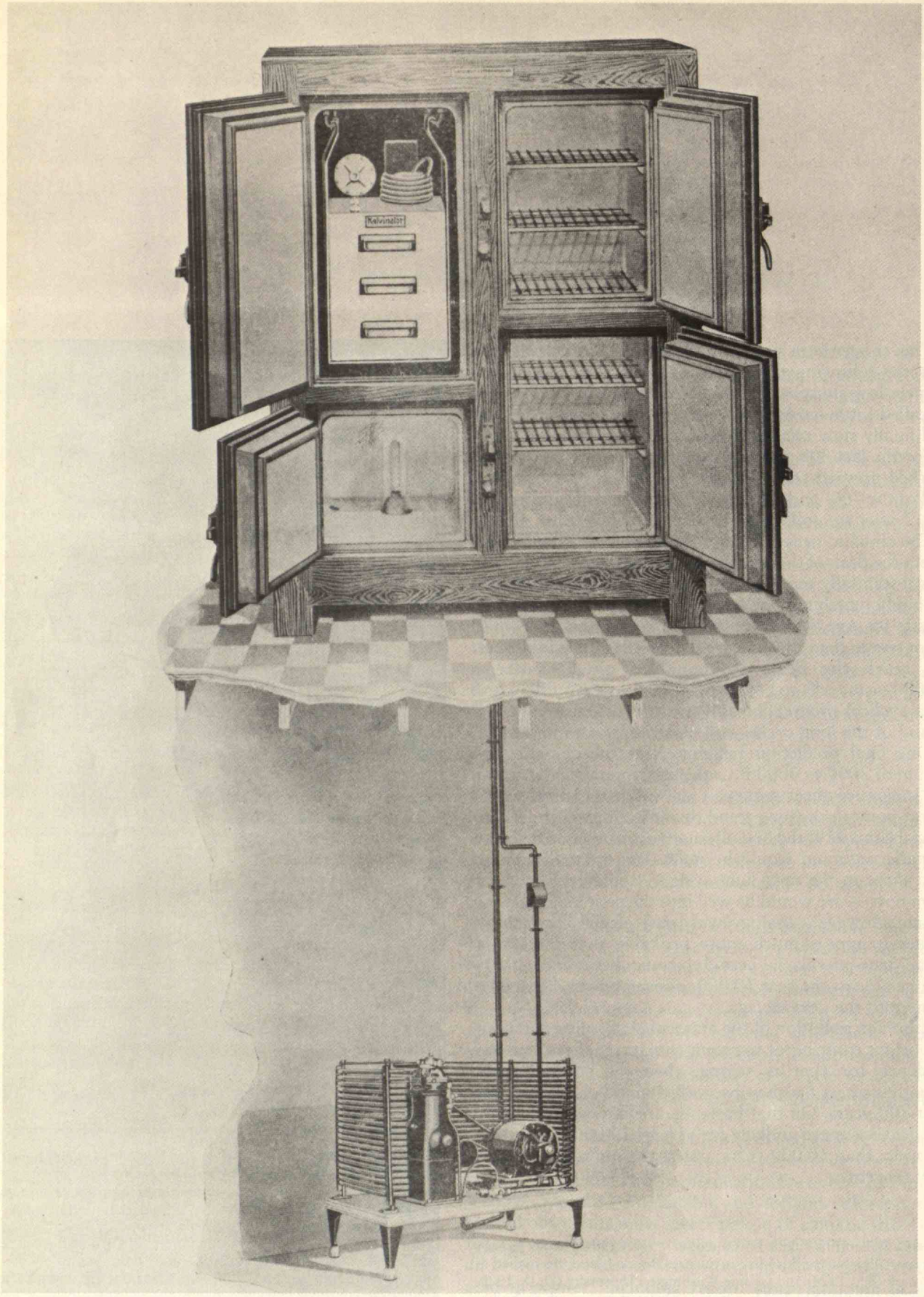
One final prediction remains. Was the climatic optimum of 2000 to 3000 B.C. the final interglacial stage in the major ice sheet sequence, or was it merely the first warm point in the long trend towards an extended interglacial climate? If the first alternative is true, then the next climatic optimum would be much less optimal, and by this phase in the next long cycle — some 10,000 years from now — we would be well into the next major glacial epoch. However, analogy with past glacial chronology makes it appear much more probable that there is a longer true interglacial period to come; hence it probably will be at least the year 30,000, or even longer, before we come into the next ice age.

If human pollution of the atmosphere is ruled out as an important contributor to recent climatic changes, and the evidence for that is strong, then the solar-climatic hypothesis best fits the observed climatic changes of the past 700 years. On that basis, by analogy with the past, the next ice age is unlikely for at least 10,000 years, even for more than 30,000 years, unless the sun takes off on a new tangent.

Hurd C. Willett first fulfilled his interests in the weather on his father's farm near Pittsburgh. Born in Providence, Rhode Island, he studied at Princeton (B.S. 1924) and George Washington University (Ph.D. 1929) before joining the M.I.T. Meteorology Department, in which he has spent almost his entire professional career. He has been honored for his central role in developing the polar front theory of weather forecasting, a natural outgrowth of his life-long interest in climatic fluctuations as influenced by variable solar processes.



The middle curve shows the average Northern Hemisphere temperature over 80 years since 1890; with what can its fluctuations be coordinated to understand their cause and make possible predictions for the future? Particulate matter in the atmosphere is proposed to absorb solar energy which would otherwise reach the earth's surface; but there is also the possibility that particulates have an opposite — the "greenhouse" — effect of increasing temperatures by trapping solar energy. Increasing atmospheric carbon dioxide due to fossil fuel combustion may also be a cause of increasing temperatures. The upper curve shows temperatures hypothesized in the absence of atmospheric particulates; the lower curve is one estimate of temperatures in the absence of any increase in CO_2. The author finds that neither can account for recent climatic trends.



The First Electric Refrigerator

George C. Newton, Jr.
Professor of Electrical Engineering
M.I.T.

Skyrocketing energy costs have made it profitable to consider more energy-efficient designs for such venerable and familiar machines as the refrigerator.

Energy and the Refrigerator

With energy costs almost certain to rise continuously for the foreseeable future, both manufacturers and consumers have become increasingly concerned over the energy used in home appliances. This is wise because the cost of energy is an important component of the operating cost of many appliances. Energy costs represent about 58 per cent of the total cost of owning a refrigerator, 28 per cent of a room air conditioner, and 12 per cent of a color television.

Also, the total energy consumed by home appliances is a significant chunk of total U.S. electricity consumption. Refrigerators account for about 20 per cent of residential electricity used in the U.S. today, or about 7 per cent of the total U.S. electricity load.

I concentrate on the refrigerator in this article because it is a good example of an appliance used in almost every household in the United States, and an appliance that has been continuously evolving since it was introduced more than half a century ago.

The Ice Man Wenteth

The first integral electric refrigerator, marketed in 1914 by Kelvinator, consisted of a simple replacement of the ice in an insulated compartment by an evaporator unit, which was connected to a compressor and condenser located beneath. During these pioneering years old iceboxes were also converted by local dealers, who made custom installations of refrigerator components. These early machines rapidly took over the business of keeping food cold and caused the demise of the ice-delivery business. Such single-door machines were cooled by an evaporator unit surrounding a freezer compartment, which was quite small relative to the total refrigerated space. In the 1950s came refrigerators with larger freezer compartments, usually accessible through a single door shielded from the fresh-food space by a light, non-insulated inner door. At the same time there appeared machines of the cold-wall type and ones with cycle-defrost, both of which eliminated manual defrosting of the fresh food space. Finally, in the 1960s came the refrigerator era we are now in, with multiple-door refrigerators featuring substantially larger freezer sections, and no-frost features, which I shall explain later.

The first electric refrigerator, developed in 1914 by engineer Nathaniel B. Wales, was eventually marketed under the name "Kelvinator." The refrigerator was essentially an ice-box with cooling coils in place of ice. The motor, compressor and condensing unit were placed either beside the unit, or in the basement. (Illustration courtesy of the Kelvinator Appliance Co.)

As the size and convenience features increased in the refrigerator's evolution, so did energy requirements. Early machines required only 6 watts per cubic foot; later machines with no-frost fresh-food space needed 10 watts per cubic foot; and many of the no-frost refrigerators used today need 14 watts per cubic foot.

Not all of this increase in energy requirements was due to "frivolous" design. The function of refrigerators also changed during the machine's evolution, with freezer volume increasing markedly until now it may be 35 to 50 per cent of the total volume of refrigerated space. Much more energy per cubic foot is needed to cool the freezer section than the fresh-food space because of the lower temperature. Also thin-wall construction has been introduced to yield a higher ratio of interior to exterior volume.

The increase in refrigerator energy requirements and the increase in the number of refrigerators have together caused the total electricity load from refrigerators to increase enormously, from about 18 billion kilowatt-hours (kwh.) per year in 1950, to 60 billion kwh. in 1965. By the year 1980, most machines will probably be no-frost with larger freezer volumes, and total energy requirements are projected at 190 billion kwh., based on data for machines built from 1966 through 1972. The home refrigerator load represents about 20 per cent of the residential load or 7 per cent of the total U.S. electrical load as of 1973. Not only is this large in absolute terms, but it is growing about 8.3 per cent per year, slightly faster than the total U.S. load.

The 1980 projected demand may not actually come to pass for several reasons. First, there are indications of a slight increase in energy efficiency of recent no-frost machines compared to those introduced in the mid-1960s. Thus, the 14-watt-per-cubic-foot figure of today's machines may dip toward 13 or 12 watts per cubic foot, purely because of forces already in motion within the industry. Also, at the behest of the Department of Commerce, manufacturers will voluntarily attach energy consumption labels to their appliances to make such information available to the consumer at the point of sale. The Association of Home Appliance Manufacturers has recently developed an energy rating standard. Many states are preparing legislation that would require some form of labeling on appliances giving their energy requirements. The Department of Commerce has also reached an agreement with a number of manufacturers to

adopt voluntary efficiency standards aimed at a 30 per cent improvement by 1980 over 1972 consumption levels.

And, finally, energy requirements may drop because it is technically and economically feasible to build more energy-efficient refrigerators, as we will see.

To help you understand the basis for improving refrigerators, I will first discuss the basic operating principles of the modern refrigerator.

How the Modern Refrigerator Works

A refrigerator uses energy to pump heat out of the refrigerated space against the outside-inside temperature difference. Although there are many styles and sizes, the top-mounted freezer units, with about 15 cubic feet of storage space are very popular. Such a unit is illustrated at the right, along with schematics of the flow of refrigerant and air flow in the refrigerator. It usually consists of a 4-cubic-foot freezer and an 11-cubic-foot refrigerator compartment. The "heat pump" which moves heat from the interior to the exterior is a heat engine running in reverse. An electric motor drives a compressor which causes a working fluid — vapor — to travel from one or more evaporators at low pressure to a condenser at high pressure. There the vapor changes to liquid form as it transfers its heat to the outside air. The liquid then is reduced in pressure, by means of a capillary or expansion valve, and enters the evaporator(s) within the refrigerator compartment where it vaporizes, thereby absorbing heat. A forced air system carries heat from the freezer and refrigerator compartments to the evaporator.

Although the heat pump is controlled in an off-on manner by a single thermostatic switch, it is possible to adjust the temperature of the two compartments by setting both the thermostat and a damper, which limits air flow to the refrigerator compartment. According to food scientists, the best temperatures for the refrigerator and freezer compartments are 37°F and 0°F, respectively. To achieve a freezer temperature of 0°F, the evaporator must operate at a lower temperature — usually −10° to −20°F — so that heat will transfer. Since the evaporator is the coldest part of the system, water vapor condenses on it in the form of frost. Periodically the normal refrigeration function stops and electric heat is applied to the evaporator to melt the frost. The resultant water is collected in a pan, where it evaporates into the room air. Electric heat is also used to warm the mullions around the doors to prevent sweating.

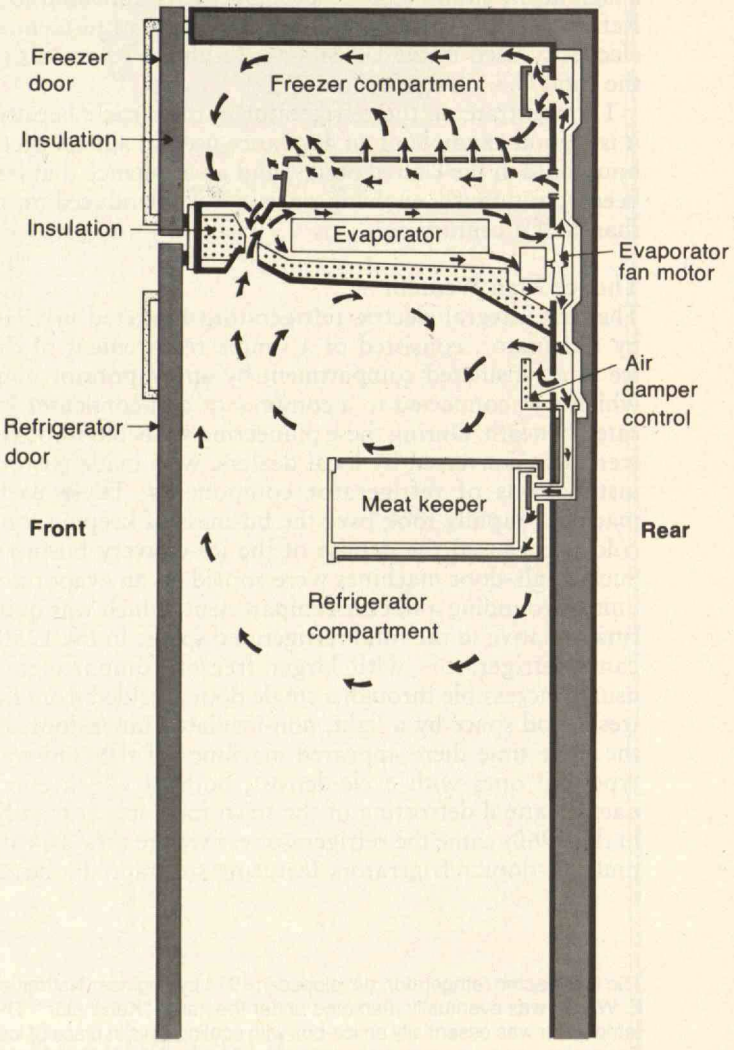
The refrigerator's heat pump (*see facing page*) is usually a "sealed system," often designed to be installed as a unit during the final assembly of the machine. Because of this sealed system concept, manufacturers have achieved unusually high reliability, as evidenced by their standard practice of guaranteeing the overall machine for one year and the sealed system for five years. The reliability is also evident from the average ten-year retention period of the refrigerator by the initial purchaser and in the long life estimated for this appliance — typically 14 years.

Where the Energy Goes

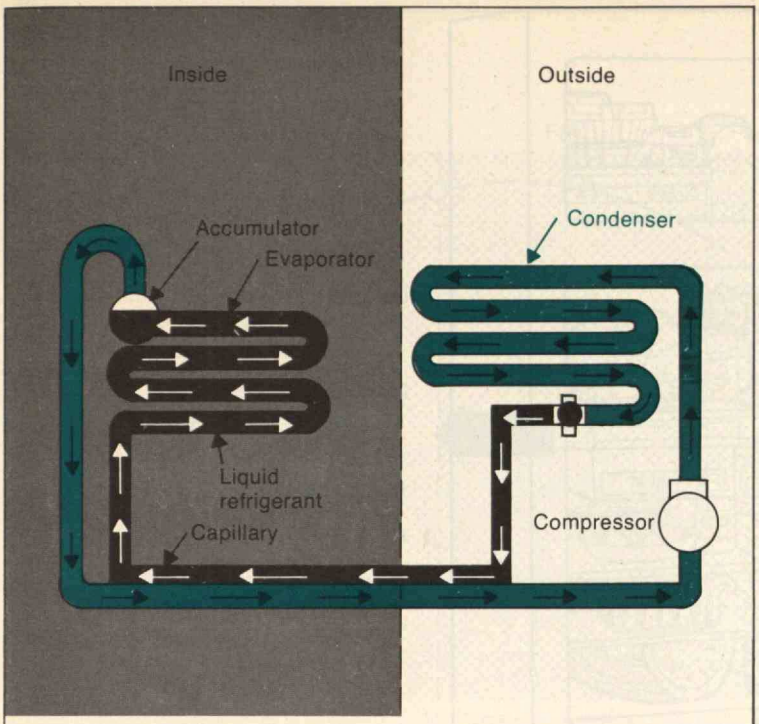
To improve the refrigerator's energy efficiency we must first learn how and where the average refrigerator uses electricity. On page 60 is shown such a breakdown for the popular top-freezer refrigerator in the mid-range capacity of 15 cubic feet.

As you can see, a refrigerator expends power in eight different ways, one of which — the compressor motor loss — accounts for more than one-fourth of the total. Next in line is the combined loss due to the mullion heaters, fan motor and defrost heater; then comes the ideal vapor compression power and finally the loss associated with the temperature rise of the condenser. These four largest items account for about 71 per cent and the other four items account for about 29 per cent of the total input power.

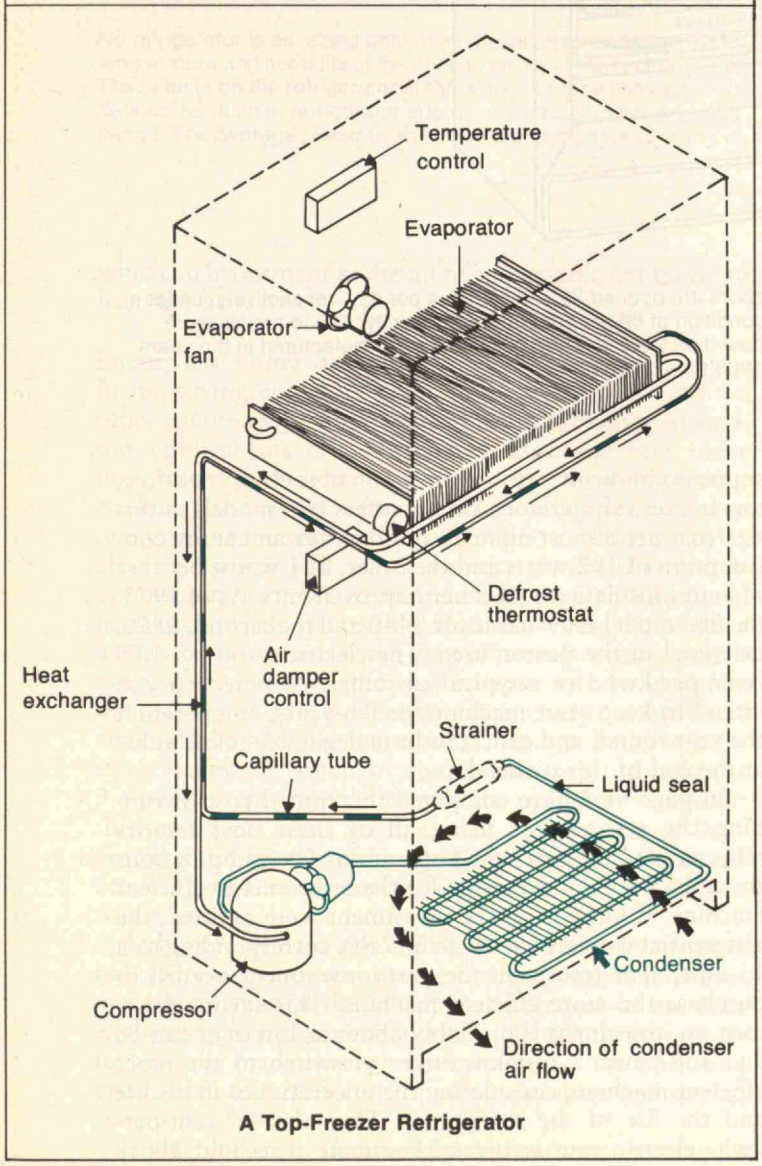
The power input to a refrigerator is determined by the "run" time of the compressor unit, which varies with changes in outside temperature and humidity; with the "live" load of ice-making and food cooling; and with the frequency of door openings. You can see the effects of temperature and humidity in the graph on page 61 of the energy consumed by a 17-cubic-foot, side-by-side, refrigerator freezer located in a Boston suburb. This one-year record clearly shows the effect of higher temperatures and humidity characteristic of summertime operation.



Air Flow in a Top-Freeze Refrigerator



Schematic of a Refrigerator's Sealed System



A Top-Freezer Refrigerator

Designing a Better Refrigerator

With knowledge of how energy is used in the refrigerator, we can estimate the energy savings achieved by various design changes. And, knowing the value of those energy savings we can compute how much a consumer could afford to pay for a particular change and still break even; if the actual cost of the improvement turned out to be less, he would save money.

For example, we could replace resistance heating by condenser tubing to prevent sweating on the mullions. According to the energy table on page 60, this would save 20 watts of electrical power or 175.2 kwh. per year. At 3 cents per kwh. this will save $5.26 each year. Paying for this improvement at the outset, however, would mean foregoing interest on a given amount of money. Assuming 9 per cent interest and a 10-year amortization period, the equal-payment amortization rate is 15.6 per cent. This means the upper bound on what the consumer could afford to pay for this design change is $33.70 ($5.26/0.156). Since the cost to the consumer of replacing the electrical resistance heater by a portion of the condenser tubing is expected to be less than this amount, this proposed change may be economically justified. Recently, however, many manufacturers have introduced switches to allow the user to shut off the mullion heater under low-humidity conditions. This approach is cheaper in first-cost than using condenser tubing and may be lower in overall cost if the user does, in fact, use the switch.

Next, we consider the effect of lowering the condenser temperature by providing more surface area. To a first approximation, somewhat more than doubling the surface of a natural-convection condenser should reduce the mean temperature from 122°F. to 101°F., with a saving of 13 watts of power for vapor compression. This corresponds to 24.4 watts of input power when motor and compressor efficiencies are accounted for. The $6.41 annual energy cost saving sets an upper bound of $41.10 on the selling price increase the consumer can afford to pay. Since this is expected to be greater than the actual price increase a larger condenser probably can be economically justified, even though it may reduce the ratio of usable to total volume of the machine.

Finally, what might be the cost effectiveness of several design changes made in combination? Assume that we:

— Increase insulation by changing from fiberglass to polyurethane foam.

— Increase the motor efficiency from 66.7 to 76.7 per cent.

— Use condenser tubing in lieu of resistance heaters to prevent sweating on the mullions.

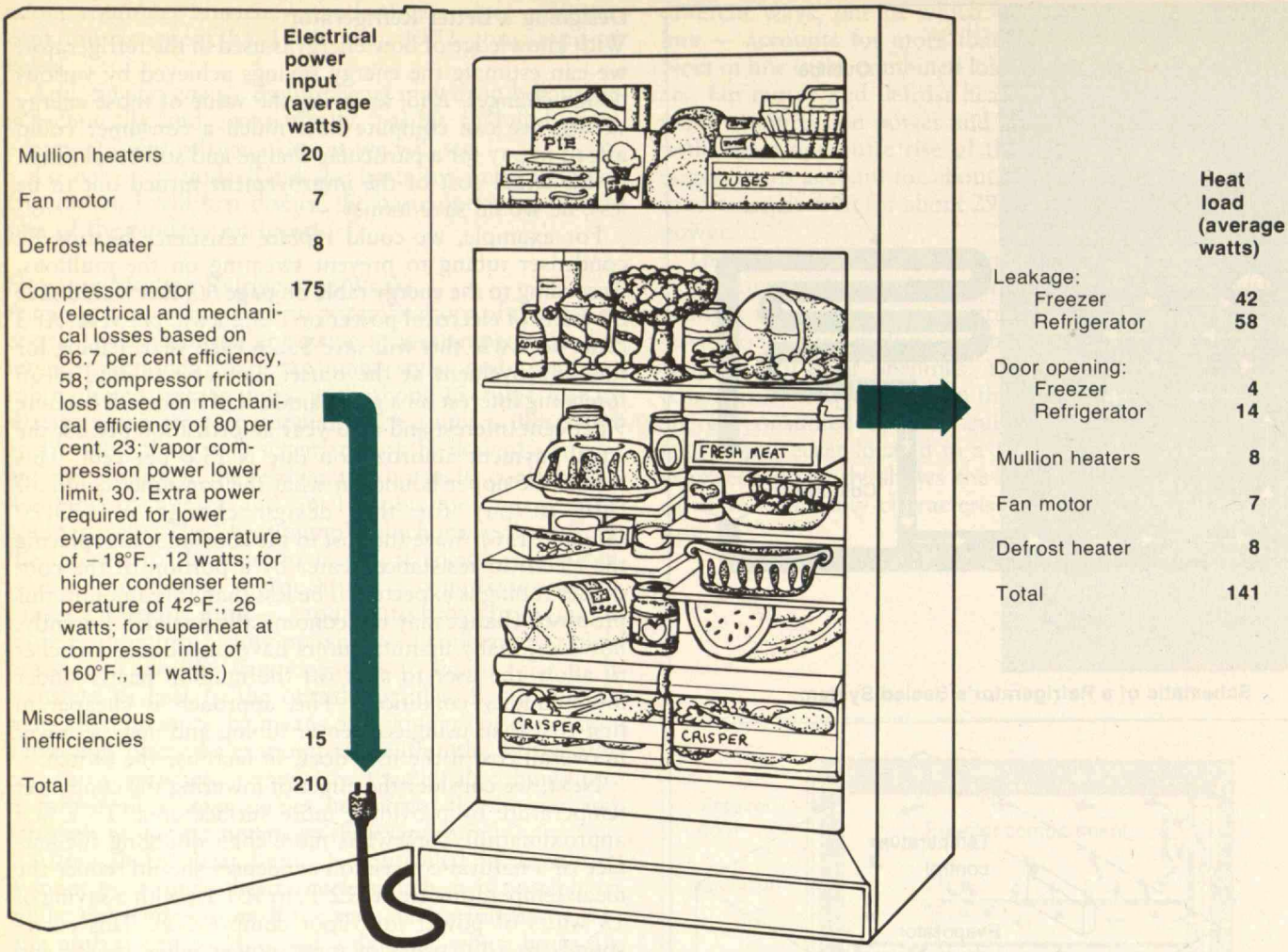
— Increase the evaporator surface to reduce the temperature drop from 18°F. to 9°F.

— Increase the condenser surface to reduce the mean temperature rise in the system from 42°F. to 21°F.

— Modify the compressor unit to reduce superheat from 160°F. to 80°F. at the compressor inlet.

According to estimates by engineer Wing S. Chow in an M.I.T. master's thesis, the insulation change would eliminate 39 watts of heat load, reducing it from 141 to 102 watts.

Based on the figures on page 60, the total input power after these six changes would be about 97 watts, in contrast to the 210 watts required before. This set of changes would reduce annual energy consumption 990 kwh., from 1,840 kwh. to 850 kwh. At 3 cents per kwh., this means a saving of $29.70. This figure places an upper



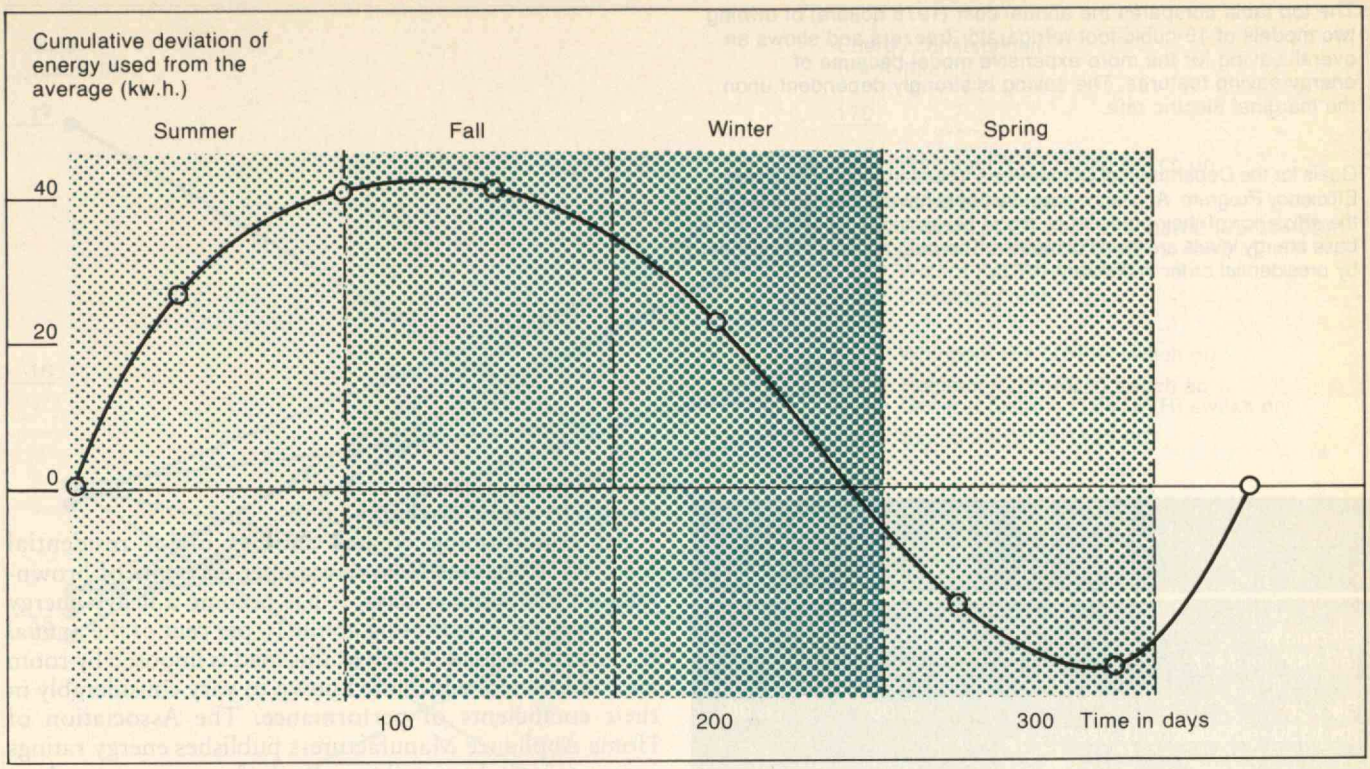
Power requirements for a 15-cubic-foot, self-defrosting, top-freezer refrigerator. The assumptions are that: outside temperature is 80° F.; the refrigerator is kept at 37° F.; and the freezer at 0° F. The author assumes the freezer and refrigerator doors are opened 25 and 50 times per day, respectively, under a condition of 60 per cent relative humidity. These results were based on tests of over 100 machines manufactured in the years 1966 through 1972.

bound of $190.50 on the increase in purchase price, assuming an interest rate of 9 per cent and an amortization period of ten years. We would expect the effect of this set of design changes on the purchase price to be less than this, so the changes appear to be economically justified. If the above changes could be made at a price increase of $90 the consumer would save $15.67 a year.

If there were complete replacement of the present refrigerator population — 70 million machines with these new machines — there would result a saving of $1.1 billion a year for the nation. Using the more energy-efficient machines would reduce the share of the residential electricity budget taken up by the refrigerator from about 20 per cent to about 10 per cent. This change would reduce the refrigerator component of the overall U.S. load from an estimated 7 per cent to 3.3 per cent, a saving of 3.7 per cent. If this reduction had been accomplished as of 1974 it could have saved 62.6 billion kwh. which corresponds to a third of a million barrels of oil a day — about 5.4 per cent of our oil imports.

In the past consumers have had little choice in the matter of energy consumption when purchasing frost-free refrigerators, but now this is changing; there are choices available if one knows how to make them. To illustrate, suppose you want to purchase a 16-cubic-foot, frost-free, top-freezer refrigerator. Amana offers two models in this size that are almost alike except one has an energy consumption of 192 watts and the other, 121 watts, because of better insulation and other improvements. As of 1975, the first model is available for $440 and the second, $550, delivered in the Boston area. The electricity rate is 4.70 cents per kwh. for a typical customer. Assume that you intend to keep your machine for ten years, to operate it the year round, and expect to have negligible resale value at the end of this ownership.

On page 62 I have computed the annual cost of running the refrigerator using all of these cost factors reflected into the first year's operation. The computations show a $7.40 annual saving for the more energy-efficient machine. If interest on the investment were omitted, the differential would increase to $17.30, corresponding to a 15.7-per-cent return on the extra investment needed to purchase the more efficient machine. This saving or return on investment is probably about as low as it can be and still cause a rational buyer to switch to the more efficient machine, considering the uncertainties in his life and the life of the equipment. Thus the 4.7-cent-per-kwh. electric rate is the approximate threshold above



No refrigerator is an island unto itself, but is affected by the temperature and humidity of the outside air, as shown in this graph. These tests on the refrigerator in the author's home showed definite variation in refrigerator energy use throughout a one-year period. The average power used for the test period was 5.19 kwh./day; the 20-day maximum was 6.20 kwh./day; the 20-day minimum was 4.66 kwh./day. The average power is lower than normal because of a 4°F. higher freezer temperature and a lower average environmental temperature than is typical.

which an investment in the more energy-efficient machine becomes attractive.

Energy and Other Appliances

In improving energy efficiency we should also examine other energy users in the home. Electrical heating in various applications is a big energy user: the four most important of these are space heating, clothes drying, cooking, and water heating, which account for about one-third of the residential consumption. Unfortunately, electric ranges and water heaters don't offer much opportunity for improvement as long as direct resistance heating is used; converting electrical energy into heat using a resistor is a 100-per-cent-efficient process, and the only way to improve efficiency is to reduce heat loss after the conversion process. For instance, electric water heaters could be improved somewhat through better insulation. James J. Mutch of the Rand Corp. estimates a 9.6-per-cent saving in energy if the optimum insulation thickness were used. Also, use of heat pumps or integrated water-heater-refrigerator units may give improved economy and energy utilization in the case of electric water heating.

Although we have not studied the clothes dryer in detail, there does not seem to be much room for improvement here, since it doesn't appear practical to use heat exchangers to recover exhaust heat. Also, only minor savings can be made through optimization of the operating cycle, such as better control of temperature and drying time.

Saving energy in electrical home heating is a complex proposition. It may be possible to use heat pumps, either alone or with solar energy. Heat pumps are essentially "air conditioners (or refrigerators) turned around," using electricity to cool the outside air while warming the inside. They use electricity more efficiently than do resistance heaters, using one unit of work to transfer two to four units of heat to the inside of a house, depending on temperatures. Although combined solar-heat-pump systems are probably economical in some areas of the U.S., they involve high initial outlays, which may discourage builders from installing them. Furthermore, as long as fossil fuels are being used to generate electricity, there seems to be little reason for not using such fuels directly for heating purposes, rather than indirectly. The coefficients of performance of typical heat pumps hardly offset the loss of energy associated with electric generation, transmission, and distribution. From an energy conservation viewpoint, general use of electric space heating by resistance heaters should be discouraged, especially since it usually costs more than other means at current and projected energy prices.

Although lighting is not considered an appliance in the commonly accepted sense, it uses energy and can be made more efficient. Despite the well-known high efficiency of mercury vapor and fluorescent lamps, the homeowner has been slow in abandoning incandescent lamps. Many students of the energy problem have urged lighting equipment suppliers to produce lamps and fixtures that would make it easier for the homeowner to change to these more efficient sources. We estimate that about 5 per cent of residential electricity could be saved by large-scale

The top table compares the annual cost (1975 dollars) of owning two models of 16-cubic-foot refrigerator-freezers and shows an overall saving for the more expensive model because of energy-saving features. The saving is strongly dependent upon the marginal electric rate.

	$440 Model (192 watt)	$550 Model (121 watt)
Electricity ($0.047 per kw.h.)	$79.50	$49.81
Service (two $30-incidents in 10 years)	6.00	6.00
Home maintenance (1.5 hours at $4.00 per hour)	6.00	6.00
Depreciation (sinking fund at 9 per cent to inflated replacement value at 5 per cent)	47.76	59.70
Interest (9 per cent)	39.60	49.50
Total annual cost	$178.41	$171.01

Goals for the Department of Commerce's Voluntary Appliance Energy Efficiency Program. Appliance manufacturers have agreed to improve the efficiency of their products by these percentages by 1980. The base energy levels are for 1972 models. The program was established by presidential order in January, 1975.

	Proposed per cent improvement in energy usage
Room air conditioners	22
Refrigerators and refrigerator-freezers	30
Freezers	25
Water heaters, gas	25
Water heaters, electric	9
Ranges, gas	30
Ranges, electric	10
Clothes dryers, gas	12
Clothes dryers, electric	6
Clothes washers	10
Dishwashers	18
Television receivers, monochrome	48
Television receivers, color	42

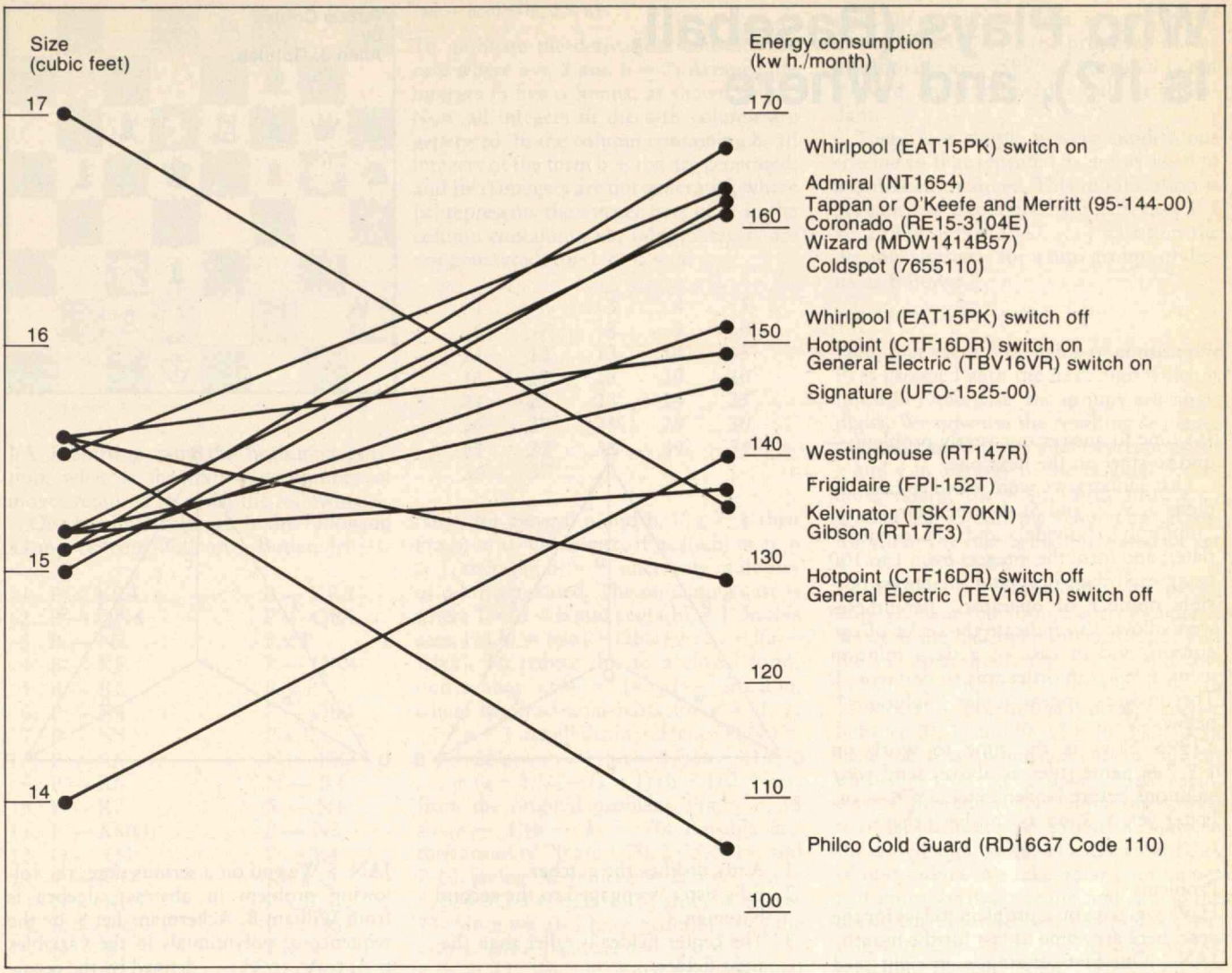
change to vapor discharge lamps.

Air conditioning creates another major residential load. As is obvious from newspaper accounts of brownouts on hot summer days, it has become a heavy energy user, perhaps constituting about 10 per cent of the annual U.S. electrical load. Much of this load is imposed by room air conditioners which are known to vary considerably in their coefficients of performance. The Association of Home Appliance Manufacturers publishes energy ratings in its guide and nameplates attached to units carry these ratings also. Thus, the purchaser has the information needed to decide wisely in buying his room air conditioner.

Finally, we come to the ubiquitous television set, which today accounts for 5 to 6 per cent of residential energy consumption. Modern solid-state circuitry has not reduced power consumption for television so much as it has for other electronic devices, perhaps because of large power losses in operating the electron deflection circuits in the picture tube. Although power required for a typical color television set has gone down from about 300 watts to about 200 watts, as the result of solid-state circuits, further reduction will probably require major modification of the deflection drives. Of course, replacement of the picture tube by some new electrostatically controlled device could result in substantial energy savings.

Energy conservation is probably the greatest challenge in the history of the home appliance industry. One step in meeting this challenge is the recent establishment of voluntary energy-efficiency goals by appliance manufacturers and the Department of Commerce. The goal is a 20 per cent average energy reduction by 1980 for 13 categories of appliances (*see left for list*). The standards were established based on the improvements that could be expected from each category.

Besides the ingenuity that the appliance industry will undoubtedly exhibit in meeting these standards, we need enlightened government energy policy. Such policy must represent a balance among many aspects, one of which is energy utilization and conservation. In this area, gradual decontrol of energy prices and more emphasis on energy-conservation research will help. And, of course, the consumer must be given the information and education needed to decide wisely about appliance purchases.



This list of energy requirements for selected typical modern refrigerators shows the variations among different brands. All the refrigerators are top-freezer, automatic defrost models, of about 15 cubic feet. When two lines are given for one refrigerator, the unit has a switch for shutting off the mullion heater — one line shows requirements with switch on the other with switch off. (The data is from the 1975 Director of Certified Refrigerator/Freezers, available for 50 cents from the Association of Home Appliance Manufacturers, 20 N. Wacker Dr., Chicago, Ill. 60606.)

Suggested Readings

Statistical Yearbook of the Electric Utility Industry for 1971, Edison Electric Institute. Publication No. 72-75, 1972.

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"Patterns of Energy Consumption in the United States," Stanford Research Institute. January, 1972.

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"Patterns of Energy Consumption in the United States," Stanford Research Institute. U.S. Government Printing Office Stock No. 4106-0034, January, 1972.

"Energy Policy in the U.S.," David J. Rose. *Scientific American,* Vol. 230, No. 1, 20-29, January, 1974.

"Appliance and Apparatus Efficiency," New York State Interdepartment Fuel and Energy Committee. June 25, 1973.

"Energy Conservation and Economic Considerations in Household Refrigeration," Wing S. Chow, S. M. Thesis, Department of Nuclear Engineering, M.I.T., Cambridge, Mass., August, 1973.

The Productivity of Servicing Consumer Durable Products, The Center for Policy Alternatives. M.I.T., Cambridge, Mass. 02139, Report No. CPA-74-4.

"Residential Water Heating," James J. Mutch. Rand Corporation, Report No. R-1498-NSF, May, 1974.

George C. Newton, Jr., Professor of Electrical Engineering at M.I.T., holds a B.S. in electrical engineering (1941) and a Sc.D. degree (1950) from M.I.T. His current research interests are in the fields of control and energy, including research in the energy aspects of consumer durables and energy utilization in transportation. He is a member of the Institute of Electrical and Electronic Engineers, the American Society for Engineering Education, and has consulted for a large number of industrial organizations.

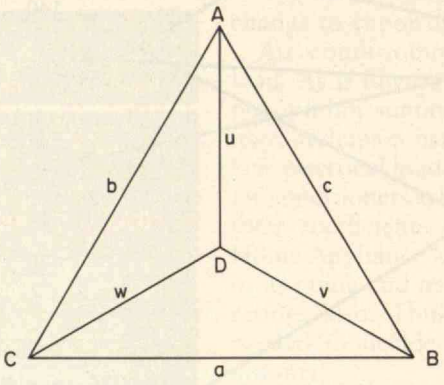
Who Plays (Baseball, Is It?), and Where

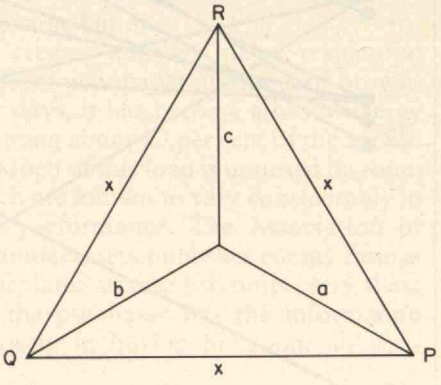
Puzzle Corner
by
Allan J. Gottlieb

It's time to answer our yearly problem — and to start on the next one.

Last January we were asked to take the digits 1, 9, 7, and 5; the operators +, −, *(multiply), /(divide), and **(exponentiate); and form the integers from 1 to 100 using each digit once and the fewest possible number of operators. Parentheses were allowed to indicate the order of operation, and in case of a tie a solution using 1 9 7 5 in order was to be favored. The answers appear under "Solutions," below.

Y1976 Now is the time to work on 1 9 7 6. Same rules as above; send your solutions before November 1, 1976 — or, better yet, as soon as you have them.





Problems

Having given you a problem to last for the year, here are some to last for the month:

JAN 1 Our first offering is an eight-card bridge problem from Emmet J. Duffy:

	♠ A 2 ♥ A 2 ♦ A 4 3 2 ♣ –	
♠ K Q ♥ K Q ♦ K Q J 10 ♣ –		♠ J 10 9 ♥ J 10 9 ♦ 9 8 ♣ –
	♠ 4 3 ♥ 4 3 ♦ – ♣ 5 4 3 2	

Clubs are trump. North leads. The problem: North and South to take all eight tricks against any defense.

JAN 2 Mary Lindenberg submits the following problem from the U.S.A. Mathematics Olympiad: Consider two triangles ABC and PQR, shown above. Angle ADB = angle BDC = angle CDA = 120°. Prove that X = u − v − w.

Jan 3 L. W. Sprodin wonders: If you drop a six-inch pencil onto a tiled floor, each tile a 12-inch square, what is the probability that the pencil will cross at least one edge?

JAN 4 The following entertaining problem, entitled "Who Plays Where?," is from Anne Goetting:

1. Andy dislikes the catcher.
2. Ed's sister is engaged to the second baseman.
3. The center fielder is taller than the right fielder.
4. Harry and the third baseman live in the same building.
5. Paul and Allen each won $20 from the pitcher at pinochle.
6. Ed and the outfielders play poker during their free time.
7. The pitcher's wife is the third baseman's sister.
8. All the battery and infield, except Allen, Harry, and Andy, are shorter than Sam.
9. Paul, Andy, and the shortstop lost $50 each at the race track.
10. Paul, Harry, Bill, and the catcher took a trouncing from the second baseman at pool.
11. Sam is involved in a divorce suit.
12. The catcher and the third baseman each have two children.
13. Ed, Paul, Jerry the center fielder, and the right fielder are bachelors.
14. The others are married.
15. The shortstop, the third baseman, and Bill each cleaned up $100 betting on the fight.
16. One of the outfielders is either Mike or Andy.
17. Jerry is taller than Bill.
18. Mike is shorter than Bill.
19. Each of them is heavier than the third baseman.

Who plays where?

JAN 5 We end on a serious note; the following problem in abstract algebra is from William B. Ackerman: Let S_i be the sequence of polynomials in the variables tr A, tr A^2, tr A^3, . . . defined by the recurrence relations

$S_0 = 1$ and

$$S_N = 1/N(S_{N-1}\ \mathrm{tr}\ A - S_{N-2}\ \mathrm{tr}\ A^2 + S_{N-3}\ \mathrm{tr}\ A^3 - \ldots + (-1)^{N-1} S_0\ \mathrm{tr}\ A^N).$$

(At this point, tr A, tr A^2, etc., should be considered simply abstract variables. For example, tr A^2 is *not* the square of tr A.) The first few polynomials are easily found to be:

$$S_0 = 1$$

$$S_1 = \mathrm{tr}\ A$$

$$S_2 = \frac{1}{2}(\mathrm{tr}\ A)^2 - \frac{1}{2}\mathrm{tr}\ A^2$$

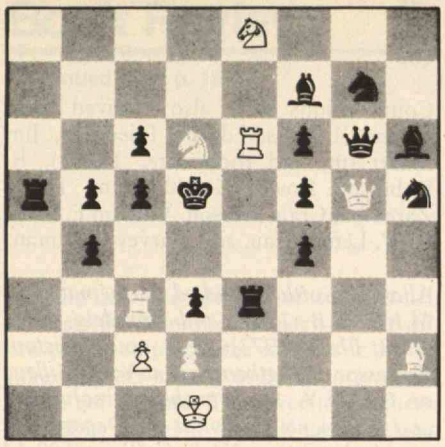
$$S_3 = \frac{1}{6}(\mathrm{tr}\ A)^3 - \frac{1}{2}\mathrm{tr}\ A\ \mathrm{tr}\ A^2 + \frac{1}{3}\mathrm{tr}\ A^3$$

$$S_4 = \frac{1}{24}(\mathrm{tr}\ A)^4 - \frac{1}{4}(\mathrm{tr}\ A)^2\ \mathrm{tr}\ A^2 + \frac{1}{3}\mathrm{tr}\ A\ \mathrm{tr}\ A^3 + \frac{1}{8}(\mathrm{tr}\ A^2)^2 - \frac{1}{4}\mathrm{tr}\ A^4$$

Now let "tr" denote the trace of a matrix, which is just the sum of the elements on the main diagonal. tr A^1 means the trace of the matrix A^1, using matrix multiplication to produce A^1 and then taking the trace of the result. If A is an N × N matrix, prove that its determinant is the value of S_N.

Solutions

The following are solutions to problems which appeared in the July/August issue.



J/A 1 Starting from the beginning position, what is the minimum number of moves required to reach the following:

Our minimal solution is the following 33 moves from William J. Butler, Jr.:

1.	P — KR4	P — KR3
2.	P — QN4	P — QR4
3.	B — N2	P x P
4.	B — K5	P — QN4
5.	B — R2	R x P
6.	P — N4	P — QB4
7.	P — N5	P x P
8.	P — R5	N — KB3
9.	P — R6	N — R4
10.	P — R7	R — N1
11.	P — R8(Q)	P — N3
12.	Q — Q4	P — K4
13.	P — KB4	KP x Q
14.	N — KB3	P x P
15.	N — R4	P — Q6
16.	N — B5	P x N
17.	B — N2	R — N6
18.	B — B6	P x B
19.	P — K4	R — R4
20.	R — QR3	B — KR3
21.	Q — N4	N — N2
22.	R — B3	N — Q2
23.	K — Q1	N — B3
24.	R — K1	N(B3) — R4
25.	N — R3	Q — N4
26.	P — K5	K — K2
27.	P — K6	K — Q3
28.	P — K7	P — B3
29.	P — K8(N)ck	K — Q4
30.	N — B4	B — K3
31.	N(B4) — Q6	B — B2
32.	R — K6	Q — N3
33.	Q — N5	R — K6

Solutions were also received from Richard I. Hess and the proposer, Paul Reeves.

J/A 2 Find integers $0 < a < b$ such that for all pairs of non-negative integers m and n the linear combinations na + nb fail to include exactly 35 positive integers, one of which is 58.

The following is a slightly modified version of a solution submitted by Frank Rubin:

To start off, find a formula F(a,b) for the number of integers *not* generated in the positive linear combinations

$\{am + bn | 0 \leq m, 0 \leq n\}$.

To motivate the derivation, consider the case where a = 5 and b = 7. Arrange the integers in five columns, as shown below. Now all integers in the a-th column are generated. In the column containing b, all integers of the form b + ma are generated, and [b/a] integers are not generated, where [x] represents the integer part of x. In the column containing κb, [κb/a] integers are not generated, for $1 \leq \kappa < a$.

1	2	3	4	5
6	~~7~~	8	9	~~10~~
11	~~12~~	13	~~14~~	~~15~~
16	~~17~~	18	~~19~~	~~20~~
~~21~~	~~22~~	23	~~24~~	~~25~~
~~26~~	~~27~~	~~28~~	~~29~~	~~30~~
~~31~~	~~32~~	~~33~~	~~34~~	~~35~~
~~36~~	~~37~~	..		

Now, for general a and b, if a = 1 then F(a,b) = 0. Otherwise, if gcd(a,b) = p, $p > 1$, then F(a,b) = ∞ since only multiples of p are generated. The remaining case is where $1 < a < b$ and gcd(a,b) = 1. In this case, F(a,b) = [b/a] + [2b/a] + . . . + [(a − 1)b/a]. To reduce this to a closed form, notice that κb/a = [κb/a] + fraction, where the fractional parts for κ = 1, 2, . . . , a − 1 are all distinct. Hence F(a,b) = b/a + 2b/a + . . . + [(a − 1)b]/a − [1/a + . . . + (a − 1)/a] = (a − 1) (b − 1)/2. Now, from the original problem, F(a,b) = 35 so (a − 1)(b − 1) = 70. Possible factorizations of 70 are 1·70, 2·35, 5·14, and 7·10, giving the values a = 2, b = 71; a = 3, b = 36; a = 6, b = 15; and a = 8, b = 11. Since we also have gcd(a,b) = 1, the only possible pairs are a = 2, b = 71; a = 8, b = 11. Since we have the additional fact from the problem that 58 is not generated, a = 2, b = 71 is not possible.

Also solved by Gerald Blum, Winslow H. Hartford, Frank S. Model, R. Robinson Rowe, E. Jamin, William J. Butler, Jr., and Richard I. Hess.

J/A 3 Produce an explicit one-to-one correspondence between the points in the unit interval $0 \leq x \leq 1$ and in the unit square $0 \leq x,y \leq 1$.

Many people offered the "obvious" correspondence, which does not quite work. The proposer starts with this correspondence and then fixes it up:

Presented with the task of constructing a single one-to-one correspondence between the points of the closed segment [0, 1] and the points of the closed square region [0, 1] × [0, 1], one may propose the following device for the required association a ⟷ (x, y): write a in decimal form; take the first, third, fifth, etc., digits to be the decimal expression for x, and take the second, fourth, sixth, etc., digits to be the decimal expression for y. Although this scheme is straightforward, it does not produce a one-to-one correspondence because it allows no simple way of consistently avoiding superfluous decimal expressions ending only in repeated 9s. Let us insist from the start that such expressions are not allowed for a, x, or y. Then if a = .50939393 . . ., the proposed device would have x = .5999 . . ., which is not allowed, and, if allowed, would be redundant.

There is a simple way to modify our scheme so that repeated 9s are avoided in a consistent manner. This modification is perhaps best explained by illustration. If a = .239943699925947 . . ., partition the decimal sequence for a into groups of digits as follows:

a = .2/3/994/3/6/992/5/94/7/. . . .

Note that every 9 or string of consecutive 9s is grouped with the next digit which is not a 9. Otherwise, the groups are single digits. We now use the resulting sequence of groups to form decimal expressions for x and y in analogy to the original procedure, taking the first, third, fifth, etc., groups for x, and the remaining groups for y. For the case being illustrated we get x = .2/994/6/5/7/. . ., and y = .3/3/992/94/. . . . Technically, our device only yields a one-to-one correspondence between the half open interval [0, 1) and the half open square [0, 1) × [0, 1). However, it is not difficult to use this device to construct a one-to-one correspondence between [0, 1] and [0, 1] × [0, 1], and, in fact, the correspondence can be accomplished in a very general way. Most useful toward this end is the simple one-to-one correspondence now provided between the closed segment [0, 1] and a closed disc of unit radius. We take polar coordinates r, θ about the disc's center and extend the above correspondence a ⟷ (x,y) by setting $\theta = 2\pi x$, r = 1 − y, and further matching the end point a = 1 with the center of the disc. It is an easy task to map the closed disc above onto a closed square region, or onto any closed and bounded convex region. This correspondence can be directly accomplished by taking as a center for new polar coordinates r′, θ', a point inside the specified region (for a square, at its center). If E(θ') denotes the radial coordinate of the point on the region's edge having angular coordinate θ', we extend the above chain of correspondence a ⟷ (x,y) ⟷ (r, θ) to (r′, θ') via the equations $\theta' = \theta$, r′ = E(θ) · r.

Responses were received from Thomas Greenway, William J. Butler, Jr., E. Jamin, Richard I. Hess, R. Robinson Rowe, Glenn Ferri, Frank Rubin, and Gerald Blum (in conjunction with G. Cantor).

J/A 4 Find four distinct positive integers such that the sum of any three is a perfect square.

Craig Gander claims the only three solutions less than 100 are

1	22	41	58
9	34	57	78
14	41	66	89

Also solved by John Unger, Gerald Blum, Frank Rubin, R. Robinson Rowe,

Richard I. Hess, E. Jamin, William J. Butler, Jr., Frank S. Model, Winslow H. Hartford, Roger Milkman, Walter F. Penny, Emmet J. Duffy, Peter Groot, Harry Zaremba, Arun Trikha, Scott Peterson, Herbert B. Wyman, Neil E. Hopkins, William Benton Fisher, and the proposer, Fritz Olenberger.

J/A 5 The problem was an acrostic, and space is inadequate to reprint it. The solution reads, "We are now in a position to illustrate how kinetic theory can supplement an empirical thermodynamic formula with a physical model," and prints of the original puzzle may be had on request from the Editors of the *Review*, Room E19-430, M.I.T., Cambridge, Mass., 02139.

Solutions were received from Harry Zaremba, Gerald Blum, W. Allen Smith, Nancy Burstein, Michael H. Auerbach, Paul McAllister, Mary Fenocketti, Glenn Rowsam, Roger Milkman, Richard I. Hess, R. Robinson Rowe, and the proposer, Dawn Friedell Jacobs. Several readers commented favorably on the problem, and Ms. Jacobs is to be complimented.

Y1975 From the four digits 1, 9, 7, and 5, construct integers from 1 to 100 using only +, −, *(multiply), /(divide), and **(exponentiate). The best answer for a given number is the one with the lowest "point value," one point being assigned for each occurrence of +, −, *, /, or **. (For a further description, and for an extension of the problem to 1 9 7 6, see the second paragraph of this column.)

No one was able to obtain 23, 41, 55, 71, 86, and 90. Several solutions purport to be exhaustive computer searches, so these numbers are presumably unattainable. The following list is from William R. Kampe III. Others equaled his total of 198 operators.

Number	Score	Solution
1	1	1**579
2	2	(19 − 5)/7
3	1	57/19
4	2	5 − 1**79
5	2	5*1**79
6	2	(51 − 9)/7
7	2	19 − 5 − 7
8	2	91/7 − 5
9	2	9*1**57
10	2	9 + 1**57
11	3	(7 − 5)*1 + 9
12	1	71 − 59
13	2	15 − 9 + 7
14	3	(1**7)*5 + 9
15	3	1**9 + 5 + 9
16	1	91 − 75
17	2	15 − 7 + 9
18	2	91/7 + 5
19	3	(7 − 5)*9 + 1
20	3	5 − 1 + 7 + 9
21	2	17 − 5 + 9
22	3	1 + 5 + 7 + 9
23		
24	1	95 − 71
25	3	5**(9 − 7)*1
26	2	71 − 9*5
27	3	5*7 − 9 + 1
28	1	79 − 51
29	3	(9 − 5)*7 + 1
30	2	(9 − 7)*15
31	2	15 + 7 + 9
32	3	(9 − 7)**5*1
33	3	(9 − 7)**5 + 1
34	1	91 − 57
35	2	51 − 7 − 9
36	3	(5 − 1**7)*9
37	3	(5 − 1)*7 + 9
38	1	57 − 19
39	3	(7 − 1)*5 + 9
40	2	(17 − 9)*5
41		
42	1	59 − 17
43	3	(5 − 1)*9 + 7
44	3	1*5*7 + 9
45	3	5*7 + 1 + 9
46	1	97 − 51
47	2	57 − 1 − 9
48	2	(57 − 9)*1
49	2	51 − 9 + 7
50	3	(1**7 + 9)*5
51	2	59 − 1 − 7
52	2	(59 − 7)*1
53	2	51 − 7 + 9
54	2	5*7 + 19
55		
56	1	75 − 19
57	2	71 − 5 − 9
58	2	1**9 + 57
59	2	(1**7)*59
60	2	(19 − 7)*5
61	3	(1 + 5)*9 + 7
62	2	9*5 + 17
63	3	(1**5)*7*9
64	1	79 − 15
65	2	57 − 1 + 9
66	2	57*1 + 9
67	2	51 + 7 + 9
68	2	(9 − 5)*17
69	3	7*9 + 1 + 5
70	3	(1**5 + 9)*7
71		
72	2	(15 − 7)*9
73	2	79 − 1 − 5
74	2	(79 − 5)*1
75	2	71 − 5 + 9
76	1	17 + 59
77	3	(7 + 1)*9 + 5
78	1	95 − 17
79	2	91 − 5 − 7
80	2	1**5 + 79
81	3	(7 + 9)*5 + 1
82	1	97 − 15
83	2	75 − 1 + 9
84	2	75*1 + 9
85	2	71 + 5 + 9
86		
	2	
88	2	(95 − 7)*1
89	2	91 − 7 + 5
90		
91	2	97 − 1 − 5
92	2	(97 − 5)*1
93	2	91 − 5 + 7
94	1	15 + 79
95	2	(1**7)*95
96	2	15*7 − 9
97	2	(1**5)*97
98	2	(19 − 5)*7
99	3	(9 + 5)*7 + 1
100	3	(1 + 9)**(7 − 5)

Contributions were also received from Richard I. Hess, Edward Friedman, Jim Stuart (my old roommate, Tulsa?), R. Robinson Rowe, Gerald Blum, Harry Zaremba, Craig Presson, William E. Peck, B. W. Letourneau, and Harvey Goldman.

Allan J. Gottlieb studied mathematics at M.I.T. (S.B. 1967) and Brandeis (A.M. 1968, Ph.D. 1973); he is now Assistant Professor of Mathematics at York College of C.U.N.Y. Send problems, solutions, and comments to him at the Department of Mathematics, York College, 150-14 Jamaica Ave., Jamaica, N.Y. 11432.

Norman

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for setting broad national energy policy, while E.R.D.A. and the Federal Energy Administration are charged with the task of putting policy into practice. And many other units in the federal government — for instance, the Departments of Transportation and the Interior, the Environmental Protection Agency, the Nuclear Regulatory Commission, the Federal Power Commission, and the Council on Environmental Policy — also have their fingers in the pie.

But the departure of Rogers C. B. Morton as Commerce Secretary and Chairman of the Energy Resources Council has again left a gap at the top of the energy policy apparatus. And with the Administration and Congress increasingly at loggerheads on virtually every aspect of energy policy — not to mention the fact that congressional committee jurisdictions are so hopelessly confused that there's no unit taking a broad legislative view of energy matters — a coherent energy strategy has yet to emerge.

In 1974, when the bill establishing E.R.D.A. was debated in Congress, a few sage observers argued that a much more ambitious reorganization of the federal bureaucracy is needed to cope with energy policy. Representative Mike McCormack (D.-Wash.) observed that simply setting up an energy hardware development agency would leave too many isolated units with a share in energy policy, and that continued confusion could result. He may well be proven correct.

Colin Norman is Washington Correspondent for Nature *and a regular contributor to* Technology Review.

Book Reviews

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and the narrower pursuit of commercial interests by domestic industry — are all present to some degree in each transnational project and by every country seeking to collaborate. The diversity of these objectives makes it difficult to assess the results. Yet the nettle of evaluation must be grasped.

Problems of management appear uppermost. Very few people know, for instance, that the Concorde project languished three years after the initial agreement was signed while the British Aircraft Corp. and Sud haggled out a common objective. The disagreements on size, range, and so on manifested a structural vacuum in which conflict resolution could only be tortuous.

This same management gap was responsible for the demise of the largest collaborative program the U.S. has joined so far. The Main Battle Tank '70, a German-American weapon for the 1970s, cost more than $400 million between 1963 and 1970 but never progressed beyond a few prototypes. Again, the impossibility of bringing two separate national management structures into agreement loaded delay and excessive cost onto the project.

The projects that worked were those in which a spirit of internationalism was more appropriate. For instance, CERN, a particle accelerator built at Geneva, was a scientific tool, not a commercial product beset by indecent rivalries over markets and production facilities. But in another case of technical collaboration — the Dragon high-temperature reactor — paralysis set in as commercial application became necessary. The five Common Market countries still engaged in the project since its inception in 1959 are meeting now to determine its fate. Dissolution is imminent though terms have not yet been set.

Looking Backward, Standing Still

The comparison of a program's results with its initial objectives may seem an obvious necessity to the authors of management textbooks, but there is no evidence of such an enterprise in Europe. From enthusiasm for collaboration in the mid-1960s, most European governments have passed without any stock-taking to a position of stasis. Little is being built now upon the foundations of collaboration so painfully laid.

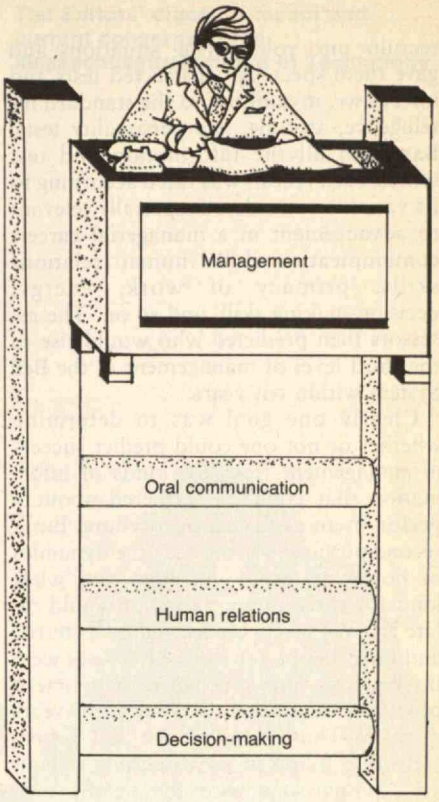
Transnational projects build in management inefficiencies. Some of the major achievements — the transfer of electronics technology in the Hawk program, the development of sophisticated systems for supersonic flight in Concorde, the reinvention of efficient management structures in Symphonie — could have been achieved at lesser cost by individual nations on their own.

Further, cooperative projects are particularly hard to monitor. Financial accountability and executive direction alike suffer from the contorted structures needed to achieve progress. The lack of responsiveness which national programs in advanced technology show toward control by representative bodies is already a subject for discontent in the U.S. as in Europe. Transnational programs impose extra levels of bureaucracy and differing political systems so that the "right of the people to know what is being done on their behalf" becomes almost a mockery.

Finally, in transnational programs, selecting the best project and adjusting the enterprise to market demands become subordinate to the political necessities of a common objective and the equal involvement of the funding agencies.

If these criticisms of transnational projects seem harsh, it is because much is claimed for them. If their principal benefit must be a contribution to international understanding, and not the right project at the right price, then we must recognize their enormous expense. Transnational projects are not the poor man's answer to the increasing cost of research and development.

Christopher Harlow is a consultant on economic studies with Peat, Marwick, Mitchell in London. He is author of numerous studies of innovation and transnational projects as Research Associate at the Institute for strategic studies. Trained initially as an engineer, he then read economics at Worcester College, Oxford.



Coming of Age in the Company

Formative Years in Business: A Long-Term A.T.&T. Study of Managerial Lives
D. W. Bray, R. J. Campbell, and D. L. Grant
New York: John Wiley and Sons Ltd., 1974; xviii + 236 pp., $12.95.

Reviewed by Edgar H. Schein

Psychologists have always been interested in human development, but only in recent decades have systematic efforts been made to study "adult development," occurring in the four decades or so between adolescence and old age. It is during this time that most of the crucial events of life take place: the building of a vocational career, marriage, child-rearing, and so on. There is no dearth of biographies, clinical studies, and theory about how adults develop. Such literature is rich in speculation about how our lives unfold, but leaves unclear which propositions are more or less likely to be true. So one can only cheer when an *empirical* study is published that deals with roughly the first decade of this critical period.

One of the main reasons why empirical studies of adult development have been sparse is the necessity to study a single sample over periods of time which may tax the researcher's patience and funds. Cross-sectional studies of groups at different ages do not permit one to assess how development occurs: individuals differ so much that it hardly makes sense to build theories on cross-sections which average such differences at the outset.

Predicting Success

Formative Years in Business narrows its focus to the occupation of "management," and examines the first eight years of this career. The data come from a sample of 274 men who were recruited between 1956 and 1958 and put through an intensive "assessment" procedure for some three days prior to employment. The assessment staff, consisting of trained psychologists and assessors, put groups of

recruits into role-playing situations and gave them specially-constructed tests and interviews, in addition to the standard intelligence, attitude, and personality tests. Based on all the information and test scores, each recruit was rated according to 25 variables considered especially relevant to advancement in a managerial career: communication skills, human relations skills, primacy of work, energy, decision-making skill, and so on. The assessors then predicted who would rise to the third level of management in the Bell System within ten years.

Clearly one goal was to determine whether or not one could predict success in management from the kinds of information that could be gathered about a person in an assessment procedure. But a second purpose was to study the dynamics of how the career unfolded and what kinds of early career variables would relate to later success. Each man was tested and interviewed annually, his bosses were interviewed, and the entire assessment procedure was repeated after eight years at work. Those who left the Bell System were also followed up to permit systematic comparisons with the people who stayed.

It was determined that advancement rates varied greatly by company and department. "Accounting" had the highest rates of promotion, while "plant" had the lowest. A global assessment based on all information available could be made for 123 recruits who still worked within the Bell System: of the 61 predicted to reach middle management, 64 per cent did reach it; of the 62 predicted to fail to reach middle management, only 32 per cent actually reached it. Of the 25 variables determining the predictions, the most significant were "oral communication skills," "human relations skills," "decision-making skills," "resistance to stress," "need for advancement," and "tolerance of uncertainty."

Certain characteristics of the early work environment also proved to be crucial predictors of later success: "job stimulation and challenge," "structured versus unstructured assignments," and a "boss who sets a good model of how to achieve success." Yet it is difficult to attribute success either to personal characteristics alone, or to characteristics of the work situation alone. These factors seemed to interact, suggesting that the best prescription for success is to hire people with high potential and provide a work environment that nurtures potential rather than permitting it to atrophy.

Growing Older and Better

An examination of changes in the group over eight years produced some surprises. For example, verbal ability, quantitative ability, and general knowledge increased in every case. The participants also became more self-confident, less dependent upon the opinion of superiors and peers, and more sure of their own goals. However, administrative skills, interpersonal skills, and overall management ability did *not* change over the eight-year period.

These changes were then related to degree of predicted and actual success in reaching middle management, with the surprising finding that only a few variables showed any relationship to success. For example, on "forcefulness," "likeableness," and "sensitivity to social cues," the predicted successes who did not in fact make middle management decline, while the actual successes who were predicted to do so remain stable, and the successes who were predicted to fail rise. This finding strongly suggests that success or failure early in the career has more effect on some personality variables than simply experience or the passage of time.

Most interesting to me was the identification of nine "life-themes," rated for each participant: occupational, ego-functional, marital-familial, religious-humanistic, and so on. It was learned that success in reaching middle management was correlated with an initial difference among the participants on certain themes that subsequent changes made sharper. For example, the successful managers were initially more involved with their work and became more so; the less successful managers became relatively more involved with their families. The authors describe the more successful people as "enlargers": people who seek new experiences and opportunities for personal growth and outward influence. The less visibly successful are described as "enfolders": people more oriented toward goals of stability, tradition, and inward strength, and who seek to stabilize and build on what they have rather than look for the new. The authors warn us that both types are adaptive and that the tendency of the "enlarger" to be more successful in management does not in any way imply that he would be equally successful in other occupations. Nor does that tendency imply any less happiness or fulfillment in the "enfolder" group.

Pitfalls of Definition

This last issue highlights both the strength and weakness of this sort of research. Following a single group within a single company for eight years and defining success as the attainment of a middle management position makes it possible to study a whole variety of relationships without ambiguity. But the assumptions that attainment of a middle management position defines what an individual considers successful, and that one can lump all the many and different management jobs into a single occupational category are clearly questionable.

My own longitudinal study of forty-four 1960s graduates of M.I.T.'s Sloan School of Management suggests that at the initial interview, there were already important differences in needs, values, and talents which ultimately influenced career development — even though what the participants said they wanted tended to be rather homogeneous. A ten-year follow-up in 1973 showed how these needs, values, and talents combined with job experience to form a "career anchor" that guides and constrains career decisions. In the group, there were some who wanted to rise to general management whose success was clearly defined by hierarchical movement up the corporate ladder. But there were others who were anchored by a specific technical/functional competence which led them to seek senior staff or functional management positions. A few participants were driven by their own creativity into entrepreneurial activity. And roughly a quarter of the group seemed anchored by "autonomy," and abandoned large companies in favor of teaching or consulting. One can only wonder whether similar differences are operating in the Bell System group, obscured by the single criterion of success as "reaching third-level management."

What of the assumption that power, influence, and responsibility are essentially correlated with managerial rank? In a society growing technologically very complex, one sees the growth of "staff" roles having as much or more responsibility as management. In the M.I.T. alumni sample, we encountered senior technical people, senior financial people, planners, and other such "staff" who were as powerful and making as much money as their managerial counterparts. Such roles tend to be neglected in company studies, though they are becoming critical to the health of organizations.

The implications of developmental research for companies are considerable. For one thing, it is clearly not enough to identify potential, even if that were possible. (One-third of the predicted successes in the A.T.&T. study never made it into middle management.) Yet there is strong evidence that a total assessment approach does improve upon chance in making initial predictions. By the same logic, it is evidently not enough simply to provide challenging work and a climate conducive to growth if the employee lacks potential.

Until we have a better understanding of how lives and careers unfold, we will not be able to deal constructively with a number of practical issues which are emerging in ever greater numbers in our society — how to "remotivate" the plateaued employee, how to help the technician move into management or some other staff role, how to deal with the high-potential person who refuses hierarchical or geographical movement, and how to deal with dual-career families.

Edgar H. Schein is Professor of Organizational Psychology Management at M.I.T. and Chairman of the Organization Studies Group in the Sloan School.

An Institute Informant

The Editors' digest of recent and current concerns at the Massachusetts Institute of Technology

The Methanol Miff

Did M.I.T. cancel research on methanol as an extender for automotive fuel early in 1975 under pressure from the petroleum industry? The charge reached *Science* magazine from an anonymous source last fall, and it was promptly denied by the Institute. Indeed, methanol research is alive and well in the M.I.T. Energy Laboratory, says its Director, Professor David C. White.

The methanol study in question began as a private venture of Thomas B. Reed of M.I.T.'s Lincoln Laboratory, who found that adding methanol to the tank improved the performance of his automobile *(see "Trend of Affairs" for March/April, 1974, pp. 61-62).* When financial support appeared early in 1974, Dr. Reed joined the Energy Laboratory to work part-time on methanol, and presently he devised a plan for a fleet test of cars fueled with a mixture of gasoline (90 per cent) and methanol. But Professor White cancelled the fleet test plan, and Dr. Reed is back at Lincoln Laboratory working on chemical thermodynamics.

Dr. Reed's plans for the fleet test were reviewed carefully by a group of M.I.T. faculty involved in Energy Laboratory activities. It was their judgment, says Professor White, that the fleet test "as conceived could not contribute reliable factual data"; he cites as problems the structure of the tests proposed and the complexity of the automobile in private operation as a test instrument.

Allen L. Hammond of *Science* was told by Dr. Reed that "the use of methanol as a motor fuel is no longer a technical question but a political one. . . . Industrial opposition to the fleet test and to the credibility it would have given methanol fuels played in my opinion a major role in the program's cancellation."

No way, replies Professor White. M.I.T. rejects that charge as "utterly false" and is in fact continuing research on methanol as motor fuel in its Sloan Automotive Laboratory — a "bench" test, not a fleet test. Professor White emphasizes that "methanol is a complex issue — an economic one, not a political one," he says.

Professor David G. Wilson (left) and Richard Wiesman (standing), a senior in mechanical engineering, review with their sponsors the first results of a study on the recovery potential of demolition wastes. With them are Robert Colonna from the U.S. Environmental Protection Agency and Charles Johnson (right) of the National Science Foundation.

New Research at M.I.T.

— Can ultrasonic energy destroy or shrink inoperable cancers by heating the malignant cells? Padmakar P. Lele, Professor of Experimental Medicine in the Department of Mechanical Engineering, is working on such therapy; he and his associates have a computer-controlled system that moves an ultrasound beam about a tumor heating it evenly to within 0.1° F., and the problem now is to determine the proper path for the beam to reach a malignant site.

— Copper, aluminum, steel, wood, lead, and glass from condemned buildings should now be salvagable for re-use, says David G. Wilson, Professor of Mechanical Engineering, following an eight-month study into potential uses of demolition wastes. But there is virtually no salvage market for concrete and plastics, and the market for bricks is unpredictable. The study will continue with a comparison of demolition industries in major urban centers throughout the U.S.

— Would superconducting motors and generators in ship propulsion systems allow naval architects significantly greater design flexibility? The superconducting units would be far smaller than conventional machines, but would they be practical in the exotic new ship concepts (above-surface platforms, underwater laboratories, etc.) that the Navy needs? These questions are the subjects of research for the Office of Naval Research by Philip Thullen, Associate Professor of Mechanical Engineering.

— A new program on delivering high-energy radiation to malignancies without damaging adjacent normal tissues has begun for the National Cancer Institute by the Harvard-M.I.T. Program in Health Sciences and Technology. Included is work on anatomical inhomogeneities,

minicomputer display systems, dose optimization, field scanning and imaging, and electromechanical components for an automated radiotherapy system.

— M.I.T.'s Sea Grant Program, conducting research, teaching, and public service activities in all aspects of ocean utilization, is assured of at least $1.4 million in financial support in 1975-76. An $890,600 grant from the National Oceanographic and Atmospheric Administration will be supplemented by matching funds from M.I.T., the Commonwealth of Massachusetts, industry, and other educational institutions.

Can Cars Work Harder On the Railroads?

Thirty years ago a box car cost $5,000. Now, when it is worn out and obsolete, its replacement will cost $25,000. Yet a new car will produce hardly more than its predecessor — an average of 16 loaded trips between origin and destination a year.

Can this problem be turned into an opportunity? Perhaps, thinks Joseph M. Sussman, Associate Professor of Civil Engineering — if it gives railroads more incentive to come to grips with the problem of increasing freight car utilization. If, for example, a box car can be made to move 24 loads a year, instead of 16, two cars will in the future do the work of three. Considering the railroads' monumental needs for new capital, this route to greater return looks attractive indeed.

After three years of research with the Southern Railway and other railroads (*see "How to Make a Railroad Run on Time," June, p. 54*), Professor Sussman and Carl Martland, a research staff member, are joining with the Association of American Railroads to monitor a national program to increase car utilization by improving schedules and reducing terminal time.

Nearly 100 railroad men came to M.I.T. early this fall to hear about the new program, and their discussions revealed that the problem is in fact full of contradictions and subtleties. America's railroad network is labyrinthine indeed. Whether a car moves quickly or slowly depends less on any railroad's management than on the efficiency of a fraternity of yard masters and dispatchers, each an independent proprietor of an independent unit of considerable complexity in its own right. Management deals with production units — trains; but the sales unit is the car, and what happens to the car depends largely on what's going on in the yards. So management has no obvious way of finding out what it's really producing. The questions on which M.I.T. will help involve finding new ways of operating yards, and new ways of assembling and routing trains so yard work is reduced — or even eliminated.

The Rasmussen Report Made Final: No Change

In 12 months since Professor Norman C. Rasmussen's Atomic Energy Commission team issued its draft Reactor Safety Study report (*see October/November, 1974, pp. 14-15*), Professor Rasmussen has received comments totalling more than the 3,300 pages on the original WASH-1400 document. Many have been useful; the final report due to appear late this year will be clearer and more understandable than its predecessor, the numerical probabilities assigned to certain accidents and consequences will be changed, and the effects on populations due to long-term low-level radiation from nuclear plants will be increased by a factor of about three.

But "there will be no major change in the accident sequences and probabilities" in the draft report, writes Professor Rasmussen in the *Bulletin of the Atomic Scientists (September, 1975, pp. 25-28).*

Professor Rasmussen and his team — they invested some 70 man-years of effort in the study — tried to identify all possible accidents in nuclear reactor operation, to estimate the likelihood of their occurrence, and to calculate the probable consequences.

Most criticisms suggested that not all possible accident sequences could be imagined and analyzed. True, responds Professor Rasmussen, who is now Head of the

Department of Nuclear Engineering at M.I.T.; but he is convinced that the most likely failure modes have been studied, and rare ones (if in fact omitted) "would not change the overall system failure probabilities significantly."

The worst consequence of a nuclear accident proposed in the draft report had a probability per plant per year of one in one billion (10^{-4}); critics have said that such numbers are simply too small to be credible. But Professor Rasmussen and his group will stand by their first analysis; as he explains in the *Bulletin*, the worst radioactive release results from an initiating event (10^{-3}) followed by the worst set of failures in systems designed to cope with this event (10^{-3}). To be most damaging, those events must all occur under worst weather conditions (10^{-1}) with the wind blowing toward the highest population density (10^{-2}). The numbers in parentheses are the individual probabilities, and added up they come to 10^{-9}.

The crucial question is whether all these events are truly independent, and Professor Rasmussen thinks that those who postulate dependences (between weather and protective system failures, for example) are proposing events "so rare that they are not likely to change the overall probability very much."

The largest changes in the final report will result from a revised estimate of the long-term radiation to the population due to the isotope cesium-137 generated in nuclear power plant operation. The American Physical Society and other commentators pointed out an error in the draft report; Professor Rasmussen and his associates have restudied their results; and "the effects related to long-term population dose will increase by about a factor of three." That is just about the limit assigned as the uncertainty in the long-term radiation data of the draft report, and Professor Rasmussen's confidence in the safety of nuclear power is unshaken.

Communicating with 75% of the Earth

Two new experimental communication satellites designed and built for the Air Force by the M.I.T. Lincoln Laboratory are due for launch in the Spring. LES-8 and 9 are different from their predecessors: they can communicate with each other as well as with ground stations. When they are in orbit, line-of-sight communication between each satellite and the ground will be possible in an 8,000-square-mile area; but the crosslink feature makes possible communications between two such areas, representing in all more than three-fourths of the surface of the earth.

The satellites are part of Lincoln's Space Communications Program, seeking "new capability to meet important military communication requirements."

Institute Review

In This Section

Persistent Divergence of Income and Outgo Prompts Tough Budget Guidelines for 1976-77

Despite reductions in the Institute's gross operating expenses which have totalled $8.2 million since 1971, M.I.T. accumulated operating deficits of $10.7 million in the two years ending on June 30, 1974, and 1975. Another $3.3 million deficit is estimated for the current year ending on June 30, 1976, bringing the total since July, 1973, to $14 million by the end of the current fiscal year.

These deficits represent the extent to which funds available for current operations failed to meet operating expenses. To cover them, the Institute has used and will use unrestricted funds "which, were they not required for this purpose, could have served as interest-bearing assets.

"The associated foregone income is about $700,000 per year."

The figures and quotation are from a report to the faculty by Paul E. Gray, '54, Chancellor, on November 19. They provided a somber introduction to the task of preparing budgets for 1976-77, in which the Institute is now fully engaged. When he spoke to the faculty it seemed to Dr. Gray "virtually inevitable that the red ink will continue" in 1976-77, he said.

Deficiencies Compounding Exponentially

The source of M.I.T.'s financial difficulty is in the differential rates of growth of revenues and expenses.

The costs of sponsored research and such auxiliary operations as housing and dining services are fully matched by corresponding revenues.

Four other components of revenue are normally available to cover the expenses of instruction, unsponsored research, plant operation, and general administration — a total of roughly $83 million in 1974-75:

— Tuition, which has recently been increased at the rate of about 7 per cent a year.

— Indirect cost reimbursement, which is tied to — and so keeps pace with — the total of indirect costs associated with sponsored research.

— Investment income, recently increasing at only 2 per cent a year.

— Gifts designated for current use, with an average recent annual growth rate of 5 per cent.

The last two of these four income streams have recently been rising at rates which are clearly less than the rates of increase in prices and wages experienced by M.I.T.

The problem is that these differentials are in rates of change; they thus compound each year to produce "chronic year-to-year growth in the operating deficit without additions to or decreases in our academic and support programs. . . . Balanced budgets tend to grow out of balance, and deficits tend to grow at an alarming rate when there is no year-to-year change in the programs of the Institute," Dr. Gray explained.

Thus the issue is far more than the relatively trivial one of balancing a single year's revenues and expenses.

A Firm Grip on Salaries and Programs

Attempting to respond to this compounding problem, the Institute has reduced operating expenses by curtailing services and programs in each year since 1970. But persistent inflation, and the necessity to improve salaries and wages to maintain the quality of M.I.T. teaching and research (about 75 per cent of the Institute's educational and general expenses represents the cost of people, Dr. Gray said), mean that the differential is not yet conquered. Nor will it be until investment and gift income can be made to grow "at rates which match the rate of growth of inflation-driven expenses," said Dr. Gray.

Indeed, he told the faculty, "our present estimate of the annual growth of the operating deficit, assuming no increase in student numbers, no growth in investment income, and no additions to program, is $2.5 million."

For 1976-77 budgetmakers, Dr. Gray outlined four tough guidelines to control ex-

penses and increase revenues:
— There must be a "tight rein" on salary and wage changes, with increases which will surely average less than those of the recent past.
— There must be a net decrease of $2 to $3.5 million, a gross reduction of $3 to $6 million, in education and general expenses; for the current year, these will be about $89 million.
— Tuition must increase; the precise amount remains to be determined, but Dr. Gray speculated on 5 to 8 per cent. (Tuition for the current year is $3,700.)
— Between 100 and 200 more students (equally divided between undergraduates and graduate students) must be enrolled.

In addition, Dr. Gray said, the Institute "will continue to press for increases in investment income" and for gifts and grants to the Leadership Campaign. Increased investment income is the obvious purpose of the Campaign's goal of $100 million for new endowment. But apart from that total, Dr. Gray said, he hopes the Leadership Campaign may generate $800,000 "in new funds which are expendable in 1976-77 on *existing* (not new) programs." □

"... When Quality and Access Are Weighed"

Financial problems are not limited to private institutions such as M.I.T.

Goods and services purchased by member institutions of the National Association of State Universities and Land-Grant Colleges rose in price by 8.6 per cent in 1974-75, and 23 of N.A.S.U.L.G.C.'s member institutions reported state appropriations which trailed this unprecedented rate of inflation.

Faculty and/or staff hiring freezes, stabilized salaries, and tuition increases were common responses at the major state-supported institutions which are members of N.A.S.U.L.G.C. Seven universities reported faculty and/or staff layoffs in 1974-75 and nine said personnel cuts would be made in 1975-76.

"The question of quality is implicit in every aspect of (this) financial crisis," wrote Ione Phillips of N.A.S.U.L.G.C.'s Office of Research and Information. Unless additional revenue is forthcoming, "the day is not far away when most of the nation's public universities must come face to face with the hard choices that come when quality and access must be weighed in the balance." □

Engineering Self-Study: Ready for Consolidation and New Programs

If engineering is a principal vehicle for economic growth, what of the profession — and the schools which teach it — in an era when growth is slowed and technological needs and goals sharply changed?

Under these conditions and under unaccustomed constraints on growth within its own environment, can "the number-one engineering institution in the country" maintain its leadership?

Pondering these two questions, the M.I.T. School of Engineering a year ago (*see January, 1975, p. 76*) mounted a major internal review of teaching, research, and administrative operations. Now a report of this self-appraisal, containing the distillation of at least 50 recommendations from 19 faculty study panels, is before the faculty and administration, and a lively exploration has begun.

In the final analysis, thinks James D. Bruce, Sc.D. '64, Associate Dean, proposals in two areas "stood out head and shoulders above all the others" in the view of the 19 panel chairmen:
— Restructure teaching in the School to consolidate subjects and "encourage curricula based on a small number of core programs."
— Strengthen and expand the School's work "in the continuing education of experienced professionals."

Four other recommendations have also attracted wide attention and interest:
— Extend "cooperative education" — programs which combine academic work with on-the-job experience — and develop a unified, School-wide program.
— Develop a "dynamic systems model" of M.I.T.'s financial operations which would help "forecast the impacts of alternative actions upon the Institute's financial position."
— Use a "task-oriented" system for planning and budgeting, to help demonstrate the effects of budget increases and decreases

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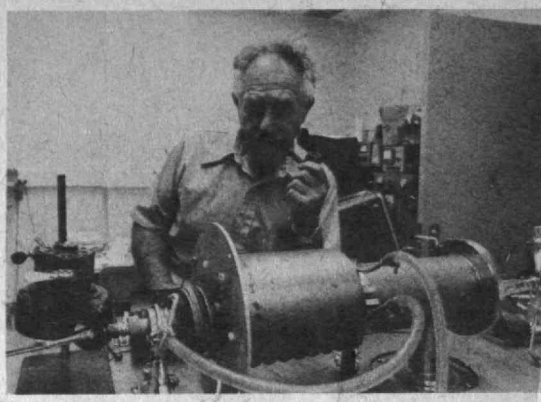
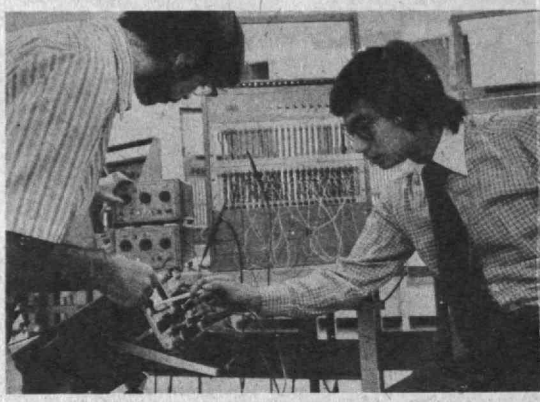
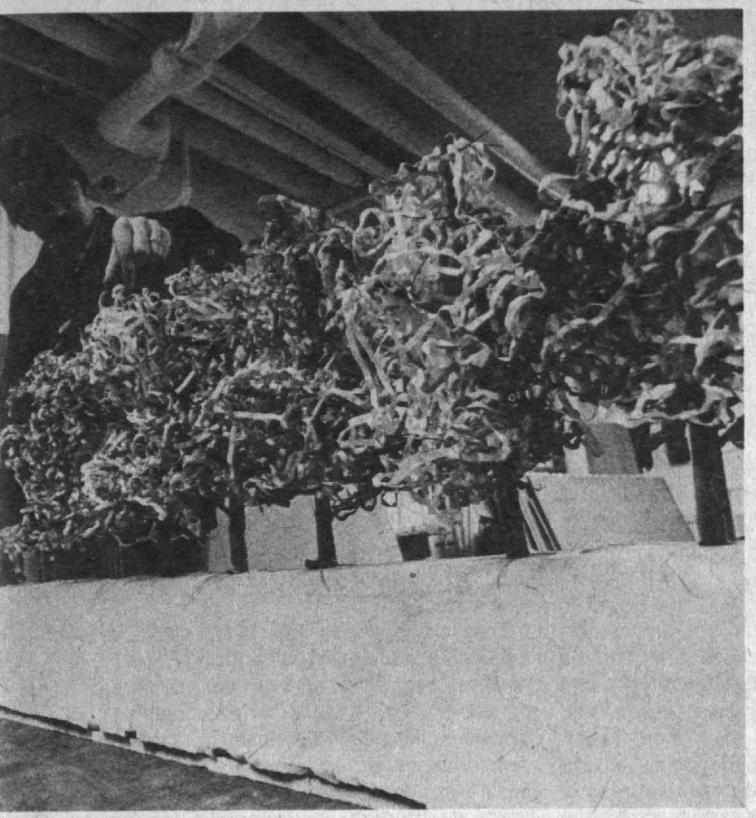
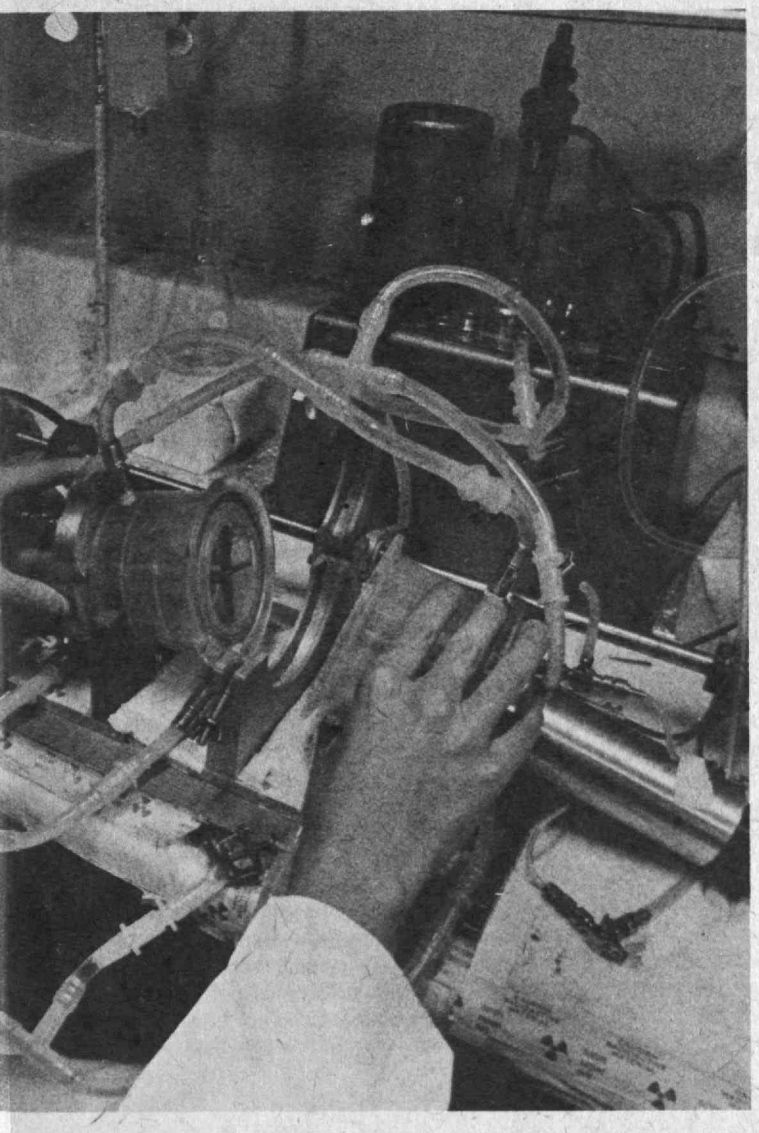
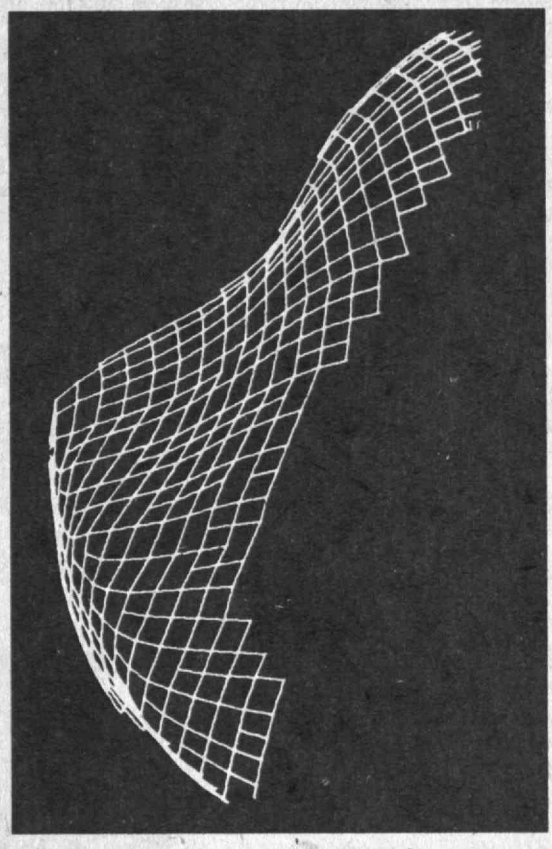




"Science, engineering, social science, and management have become essential partners," writes President Jerome B. Wiesner, "in the search for an understanding of broad problems that have awesome complexities. . . . Dealing with such issues requires an understanding of the basic science that governs their components, the technology through which basic principles can be directed to form human systems, the roles of individuals as participants in systems, and their complex interrelations in evolving societies." It is what President Wiesner calls "a new challenge for education and leadership," and a School of Engineering self-appraisal focussed most of its attention on those issues. (Photos: Ivan Massar from Black Star)







on specific programs within the School.

— Continue to encourage early retirement, beginning perhaps at age 55, for members of the faculty whose experience and interest appears to be outside the mainstream of their department's current activities.

As the dialogue begins, Dean Bruce is careful to emphasize that the self-study "made no attempt to derive a sense of consensus with regard to its recommendations," and it is that process which is going forward now throughout the faculty and indeed throughout the Institute, he says.

Consolidating Interests into Communities

From an engineering education, says the self-appraisal report, students have four reasonable expectations:

— A solid foundation in the engineering sciences.

— An understanding of the relations between technology, society, and the natural environment.

— An ability to synthesize and design.

— An ability to conduct individual and group projects and studies.

While accomplishing these goals, says the report, effective curricula should also "develop the student's imagination and abilities to conceptualize and think."

The key question in the self-study's most important — and controversial — recommendation is whether these goals can be accomplished with equal or greater efficiency in less-diverse curricula. The panel on Delivery, Cost, and Alternatives of Engineering Degree Education, chaired by Frank E. Perkins, '55, now Acting Head of the Department of Civil Engineering, thought so, citing as prototype the core program structure of undergraduate curricula in the Department of Electrical Engineering and Computer Science.

In his summary of the self-appraisal project, Dean Bruce gives an example in relation to the teaching of structures: "We have individuals actively teaching and performing research in structures in three or four departments. For the most part, these individuals work alone; but they work, nevertheless, in the same area on the same types of problems.

"If we had an amalgamation of these individuals into one cooperating community," said Dean Bruce, "it would be without doubt the strongest structures community in any university in the country."

Students tell Dean Bruce that there is "tremendous overlap" in present undergraduate engineering curricula, and he thinks consolidation would eliminate some of this, achieve economies of scale, and help reduce costs. But even more important, he says, "is the pedagogical advantage of emphasizing the common areas of engineering," and he thinks the broad, interdisciplinary problems in which most engineers are engaged today make such emphasis especially important.

It works in the Department of Electrical Engineering and Computer Science, says Dean Bruce. Every undergraduate takes a common core of four subjects: Introductory Network Theory (6.011), Signals and Systems (6.015), Structure and Interpretation of Computer Languages (6.031), and Computation Structures (6.032). Then the curriculum divides into two paths, one for students concentrating in electrical engineering itself and another for students concentrating in computer science; there is a further split in electrical engineering for students with a special interest in bioelectrical engineering, and there are other elective sequences in both electrical engineering and computer science.

Education as an Infinite Process

The traditional view that "formal education virtually ends after a student's first college experiences" is "shattered," says the self-study report. "In no field of engineering is it possible to function today without learning new material."

The self-appraisal finds M.I.T.'s role in continuing education inadequate ("M.I.T. does not help the majority of the engineering community — the experienced professionals — fulfill their potential"), and it suggests a variety of remedies:

— Greater opportunities for part-time graduate studies, including off-campus teaching and on-campus evening courses.

— A new Master's-degree program which substitutes course work for a thesis (which is often impractical for employed engineers).

— A plan for completing Master's theses in absentia when approved and supervised by faculty.

— Further emphasis on special short courses.

— Experiments on cable television for taking educational programs off the campus, and more extensive use of prepackaged audio-visual "courses."

"Clearly, we at M.I.T. are faced with significant opportunities in the continuing education area," says Dean Bruce. □

A New Engineering Dean in Education

Ernest G. Cravalho, Associate Professor of Mechanical Engineering who is highly regarded as a teacher and for research on the applications of cryogenics to biology and medicine (*see his article, "The Cryopreservation of Living Cells," October/November, pp. 30-37*), is now Associate Dean for Educational Programs in the School of Engineering.

Dean Alfred H. Keil says his assignment will be in large part to evaluate and implement the educational recommendations of the School's 1974-75 self-appraisal (*see above*).

Dr. Cravalho succeeds Professor Frank E. Perkins, who has been Special Assistant to the Dean for Educational Programs since 1973; Professor Perkins is now Acting Head of the Department of Civil Engineering (*see October/November, pp. 100-101*). A graduate of the University of California (Berkeley), Dr. Cravalho came to M.I.T. in 1966 and has been for several years an active leader in academic affairs. He has established a reputation as an effective and outgoing counselor of students, having served as junior faculty resident in MacGregor House from 1970 to 1974.

E. G. Cravalho

"To Understand and Manage a Complex Industrial Society"

The following are excerpts from statements about the School of Engineering in connection with the Leadership Campaign by President Jerome B. Wiesner and Dean Alfred H. Keil:

The traditional work of the engineer is to design and develop new structures, processes, and products whose success is measured by their technical and economic feasibility as well as by their performance. This describes the practice of engineering up to the early part of this century.

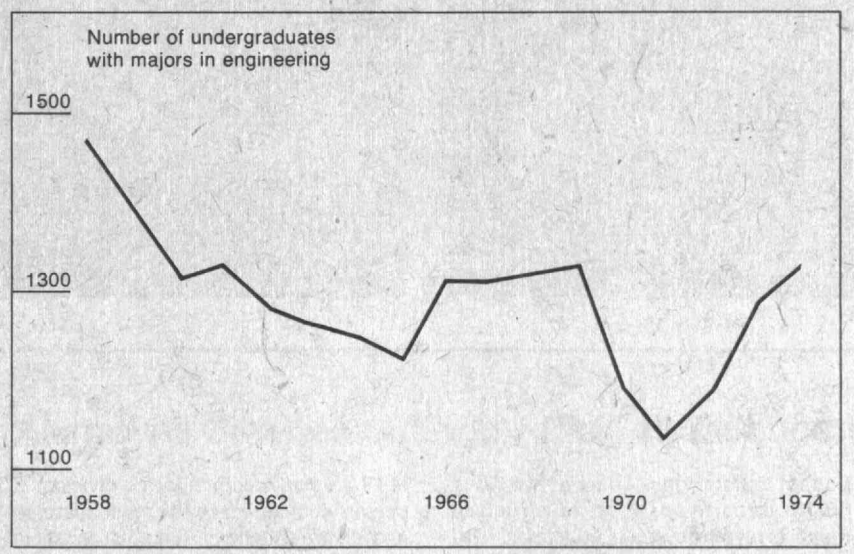
The Upward Trend of Engineering Study

Undergraduate engineering enrollment at M.I.T. is increasing, and President Jerome B. Wiesner calls it "perhaps the most important trend to emerge in recent years."

Some 45 per cent of the Class of 1978 — this year's sophomores — who had designated a major by the end of September had chosen engineering, and 44 per cent of all M.I.T. sophomores, juniors, and seniors are now in engineering — up from 36 per cent in 1971-72.

Recent growth has been primarily in the Departments of Electrical Engineering and Computer Science, Mechanical Engineering, and Chemical Engineering, according to Alfred H. Keil, Dean of the School; and he cites a special interest among engineering students for "hands-on" operations and "in exploring ways to apply what is learned."

There is a national trend toward engineering among college students, widely attributed to the relatively better employment prospects which engineers seem to be enjoying. But President Wiesner thinks the "resurgence of interest" in engineering is "more pronounced at M.I.T. than elsewhere"; and he attributes it at least in part to "the School's rededication to furthering the evolution of the engineering profession in response to broadened professional scope, including the engineering sciences and technologies, the process of engineering (i.e., the conception and development of reliable and economical technical solutions), and the process of planning responsible uses of technology." — *J.M.*



The number of M.I.T. undergraduates who choose to major in fields of engineering has been — in general — declining since the 1950s. But the number is sharply up since 1971-72, and President Jerome B. Wiesner thinks it is "perhaps the most important trend to emerge in recent years" in undergraduate education at M.I.T.

In the last half of the 20th century two developments have added significant breadth to the engineering profession. First, the range of problems to which engineering can be usefully applied has been significantly extended by new information; for example, engineering has been coupled with the life sciences as we have learned that the systematic application of technology has great potential for improving medical care and health care delivery. Also, the achievements of engineers have resulted in complex systems, such as today's networks for electric power generation and distribution, which are themselves the subject of engineering study; thus the scope of engineering practice has broadened to include the integration of new products and devices into the larger technical systems in which they must function.

Second, with the scope of engineering enlarged and the complexity of our society a growing problem, an increasing number of engineers must understand the social, economic, political, and environmental implications of their products and be prepared to evaluate the extent to which they may meet the needs of society. Engineers, who were formally called upon to contribute through design and construction, are increasingly expected to help make decisions on *what* to design and build, as well as *how*. They must foresee the consequences of their work, and they must be prepared to identify alternatives.

Thus new dimensions are necessary in engineering education. The traditional disciplinary base of the engineer in the physical sciences and mathematics must be expanded to include essential elements from the social, management, and life sciences. These added dimensions are in no sense a dilution or weakening of engineering education. Rather, they represent a dramatic reaffirmation of the basic objectives of engineering within a new set of conditions brought about by continuing scientific and engineering advances, the rapid growth in society's dependence on technology, and the resulting increase in complexity and interdependence.

A New Role for an Old Profession

Today's engineering education seeks to reassess the role of engineering in a technological society, to involve students in the responsible and humane uses of technology, and to offer a spectrum of experiences that will enable them to find the opportunities that match their aspirations and interests.

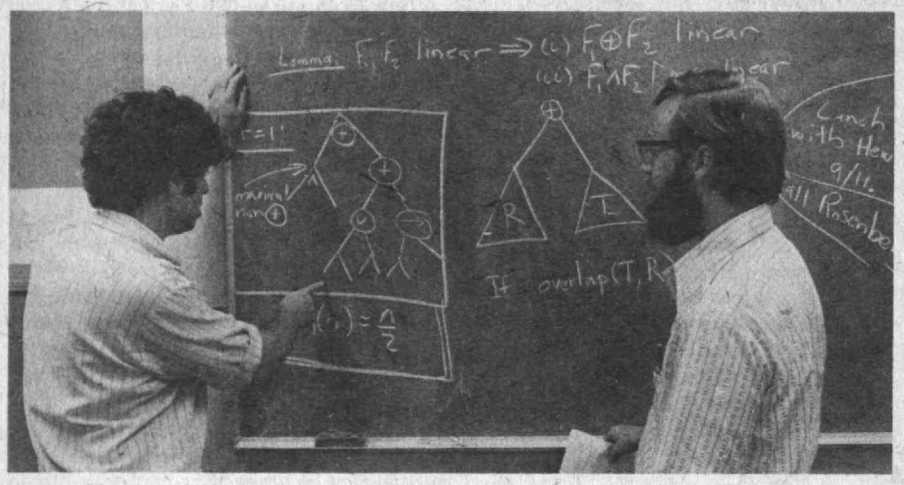
Today almost half of M.I.T.'s undergraduates who have chosen their major field, and almost half of its graduate students, are enrolled in the eight departments of the School of Engineering.

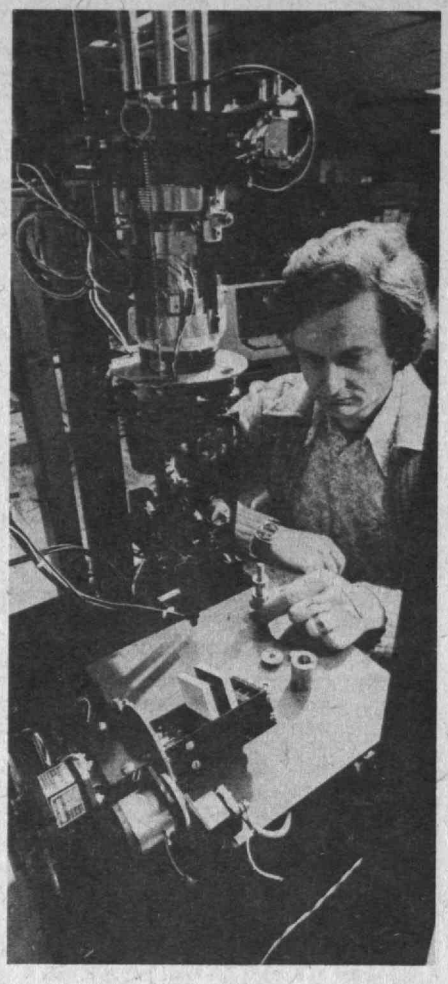
These students learn the traditional, fundamental elements of engineering education. They acquire a solid foundation in the basic and applied sciences and in economics on which they can draw during their lifetimes as they apply the steadily growing body of knowledge to engineering solutions. In addition, they enjoy new opportunities to understand the context in which they will work as they develop and apply their knowledge for truly human purposes in a society that is increasingly dependent on science and technology.

To Manage a Complex Industrial Society

As we enter the last quarter of a century whose central feature has been the rapid advance of science and its application, our greatest challenge is to understand and manage our successes within the framework of a vigorous and constantly evolving free enterprise system. The advances have increased our quality of life and our freedom of choice, but they have also increased the size and complexity of society and thus compounded a formidable array of technological and social problems. This is the central dilemma of our times.

Simply put, our task is to learn to manage a complex industrial society, to allocate and use our technological and social capabilities in a constructive and responsible manner. It is a task in which no modern system of governance — democratic, communist, or fascist — has thus far been successful. For us the difficulty will be greatest, for our need is to make more responsive, equitable, and subtle the most effective, humane, and productive society that has ever existed. □





James D. Bruce: "The Person to Talk To"

When the School of Engineering resolved to do its self-appraisal (see p. 74) *a year ago, the management of the study fell to James D. Bruce, Sc.D. '64, Associate Dean. Now that the job is finished, explaining its results is also Dean Bruce's task.*

Michael D. McNamee, '76, editor of The Tech, *found the self-appraisal report a "dull volume," full of "turgid, dry prose." So he went to see Dean Bruce, with the following editorial tribute as a result:*

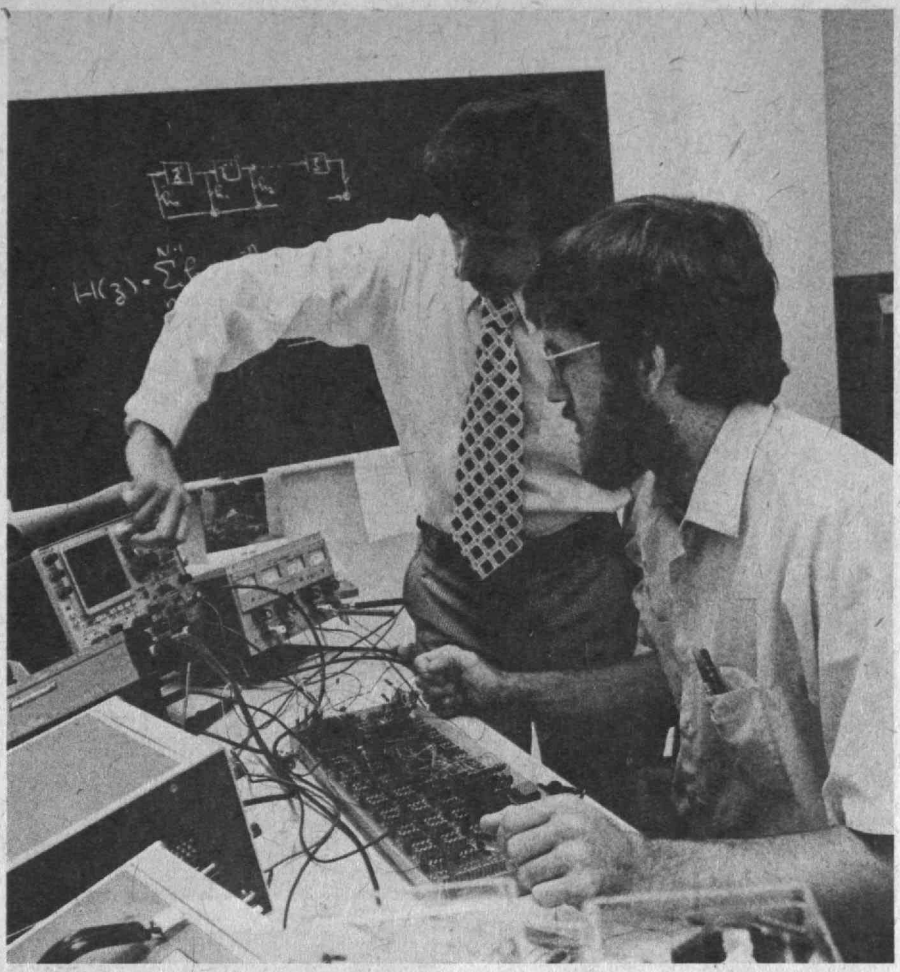
Even the driest M.I.T. report usually has some person behind it who can make it come to life, and this one is no exception. Associate Dean James Bruce, who directed the self-appraisal project from its inception a year ago, is the person to talk to to put the report into context, to make the facts and figures take meaning beyond their surface appearances.

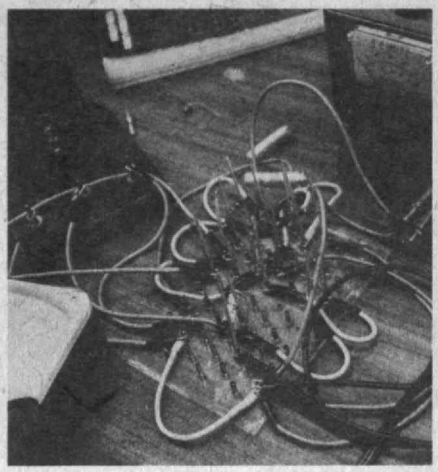
When Dean Bruce talks about restructuring the School of Engineering, for example, he's not talking about bureaucracy or how many secretaries are going to be assigned here, there, or yonder. The issue becomes tasks, jobs, purposes, existences — what would a center/department type of structure mean to undergraduate education, and what difference would it make for graduate students? Would this type of structure do more for making M.I.T. engineers more socially useful, or would decentralizing it more make it a better educational structure? The minor problems fall away, the question becomes "What is the point of this School and how do we achieve that?" — and the discussion is mesmerizing.

Similarly, a discussion of Dean Bruce's second favorite topic in the report, expanding M.I.T.'s commitment to continuing education, exposes deep-seated feelings, long hours of thought, disdain for the petty and a feel for sweep, grandeur, and importance. How can M.I.T. best serve industry, the government, other technological employers? What sort of programs does the Institute need? What sort of structures to support those programs? Why do this at all?

Dean Bruce is hardly unique. As I've said, there is at least one such professor, dean, or functionary to almost every M.I.T. report, committee, or division, a person who can make the most abstruse and abstract actions seem, at least, to be real. Their view may not be the only one on the set of issues with which they deal — their view may not even be the "right" one, by whatever index you wish to place on that — but their grasp, their feeling, their dedication is evident and sweeping.

Over the last three years I've had occasion to talk to many of these people, to grasp a little of the excitement with which they approach an issue and delve into it, to get a feeling for what a report or paper *is*, far beyond just what it says. In most of these cases, I've tried to transcribe their comments, translate their feelings, put it all down into ink on paper — and usually failed. There doesn't seem to be any way to communicate the excitement of an important point in the dry and dull forms that journalism prescribes, and I often end up with a newspaper in my hands wondering how in the world any reader can possibly grasp why the faculty or the reporters are up in the air over something. □





Alumni as Sources of Engineering Reality

Two goals of the School of Engineering for its undergraduates:

— They must know the principles of engineering and be able to assess the effects of engineering developments.

— They must understand how to apply their knowledge to projects and problems.

Classrooms and laboratories are sufficient to the first purpose, thinks Alfred H. Keil, Dean of the School of Engineering; but he hopes M.I.T. alumni can have an ever-increasing role in helping students understand the real issues they will encounter in doing their jobs in the future.

At least eight possible routes for interaction between alumni and the School were outlined by Dean Keil to members of the Alumni Advisory Council at its November meeting:

— Cooperative work-study programs, attracting greater interest among undergraduates, at companies in which alumni are employed, can give alumni prominent roles in the educational process.

— Informal (or perhaps even formal) summer work-study programs at such companies will have the advantage of providing students with income as well as experience.

— Junior faculty, too, would benefit from summer work-study programs to enhance their experience.

— Could alumni help supervise Master's-degree theses written at off-campus locations? (Dean Keil admits the issue of off-campus theses, though they are recommended in the School of Engineering self-study completed last year (*see p. 4-5*), is a "hot potato.")

— Could alumni be members of thesis committees for Ph.D. students? Dean Keil speculates that such assignments would be "interesting learning experiences" for alumni and that students, too, would benefit "from a different point of view" on the committees.

— Alumni participation in on-campus engineering research would present an "unusual opportunity" for sharing talents and viewpoints "in a learning mode."

— The faculty's recent approval of adjunct professorships gives the School new opportunities to bring practicing engineers to Cambridge and to send students to engineering offices off-campus.

— Let alumni help with "pre-professional counseling" for engineering students. "We are so close to the engineering profession," said Dean Keil, "that we fail to give students a broad picture of where the profession is going and what opportunities may be open."

Professor Ernest G. Cravalho, Associate Dean of the School, agreed; engineering educators, he said, are "lousy professional role models; the things we do are simply not representative of professional practice." A student graduating in mechanical engineering comes to Professor Cravalho to ask what a mechanical engineer really does, and Professor Cravalho has to admit that the faculty cannot really tell him. □

Shades of Meaning in "Arttransition"

In the broad view, art represents the communal ideals, values, and psychological state of a society, and the artist, the focus through which these ideas flow, should be supported as an integral part of a society's quest to understand itself. The commonly held, narrow view — that the community is the artist's audience, and its duty is to support the valued personal expression of the individual artist — is obsolete.

"Ancient Grecian and Roman art became the central configuration of the common ideals of the community. It's only in the last 400 years we made a work of art socially useless," says James Ackerman, Professor of Art History at Harvard University. Art in today's society represents a collapse of communication. "From kindergarten on, the concept of 'creativity' is the core in art — 'express yourself' — make something 'unique,' as if the individual psyche meant more than the common goal," he says. We overemphasize individuals in isolated roles; we must instead seek the value of brotherhood — and create images out of ideas, so that art can be a force in the reestablishment of our fragmented communities.

Professor Ackerman was one of some 250 artists, art theorists, and art organizers who came to M.I.T. in the fall to examine the development and role of the arts in contemporary society. "Arttransition," it was called: an international conference on art and technology, sponsored by M.I.T., the National Endowment for the Humanities, the M.I.T. Center for Advanced Visual Studies, and the University Film Study Center.

"Art as a Social Enterprise"

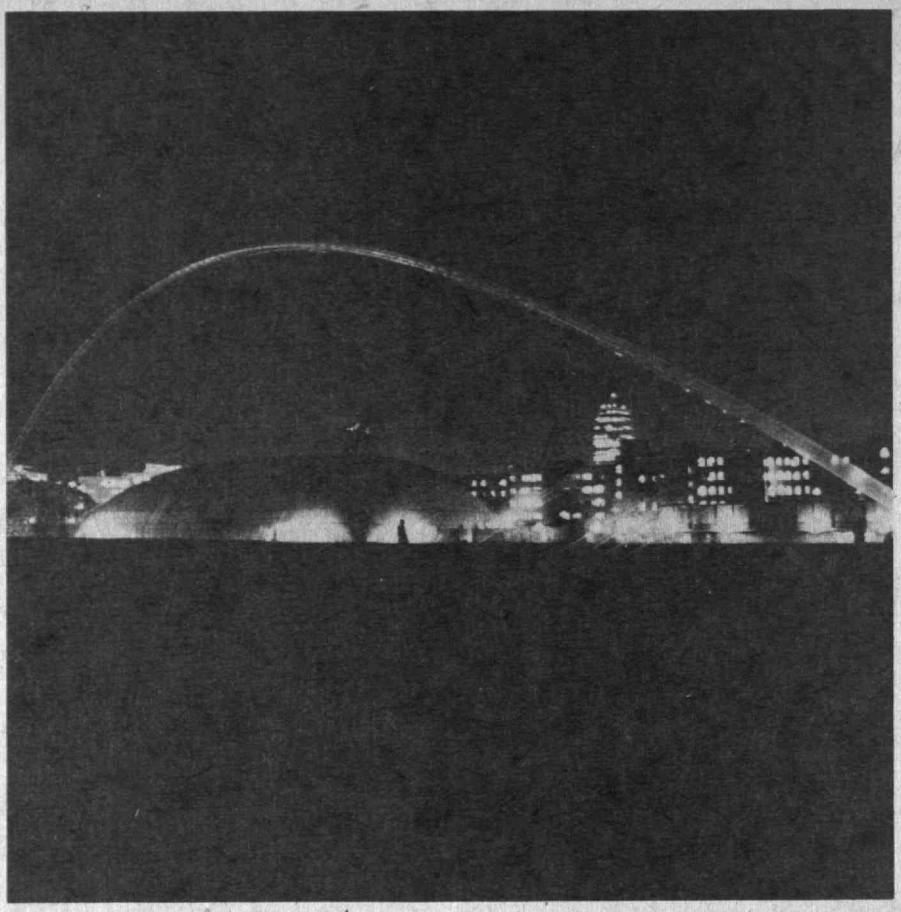
We think of education as the giving of skills, says Professor Ackerman. But this is a problem in art because the techniques of the arts are so intimately related to what there is to say. If the subject is philosophy, one can use old words to express new thoughts. But if an art teacher teaches collage, he is equipping students to say what was said in 1910. In art, new ideas need to be expressed by suitable new inventions. Some chose the vocabulary of cubism, for instance.

"Art should be seen as a social, ethical and political enterprise," said Dr. Ackerman at "Arttransition"; "art education as a way of seeking common goals. Think more of meaning, of the aspirations of mankind; ask questions on behalf of humanity," he said.

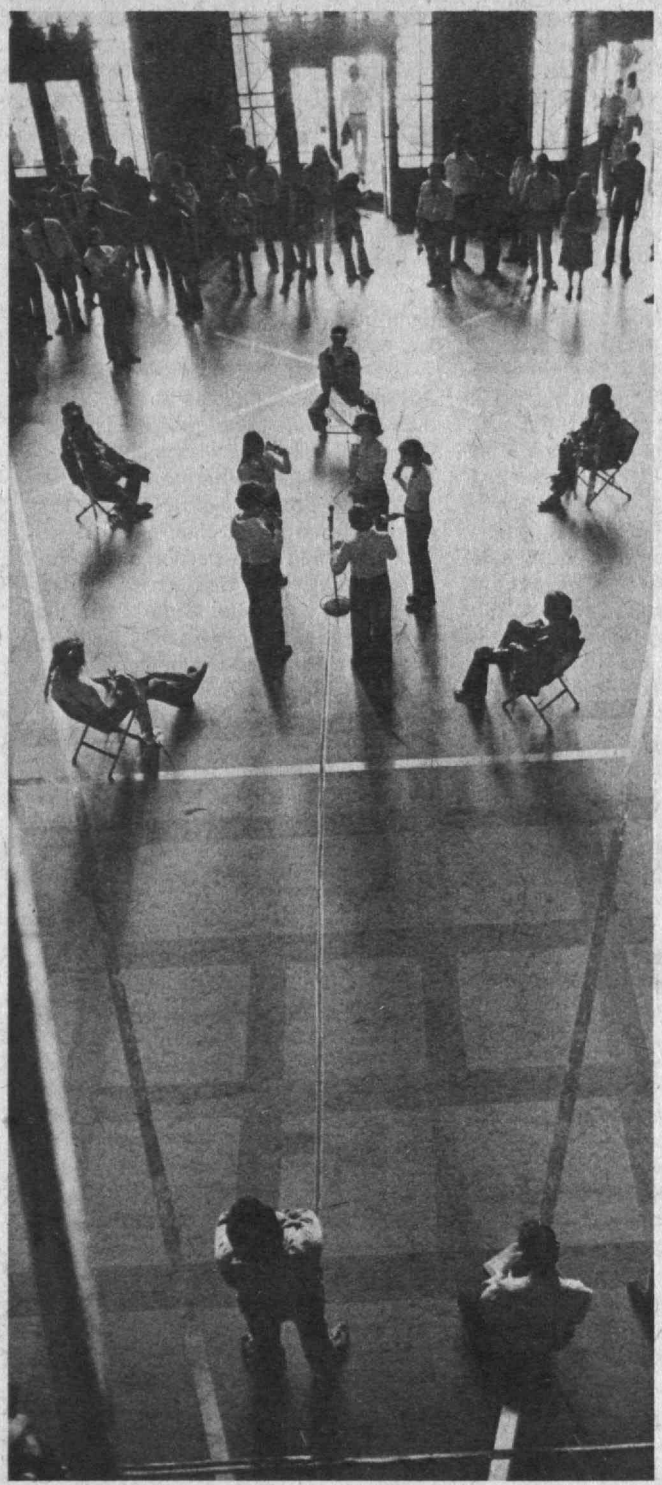
Bridging a Gap in Cognitive Styles

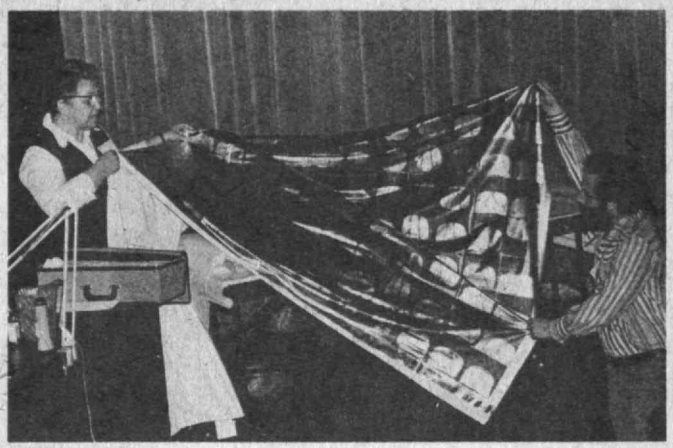
Dr. Jerome Wiesner, too, wants the arts to be a reflection of society. It would be wrong, he said, to have complacent art in a searching society. "Most of us like to believe the artist is the perceiver of society's illogic. His

continued on p. 82

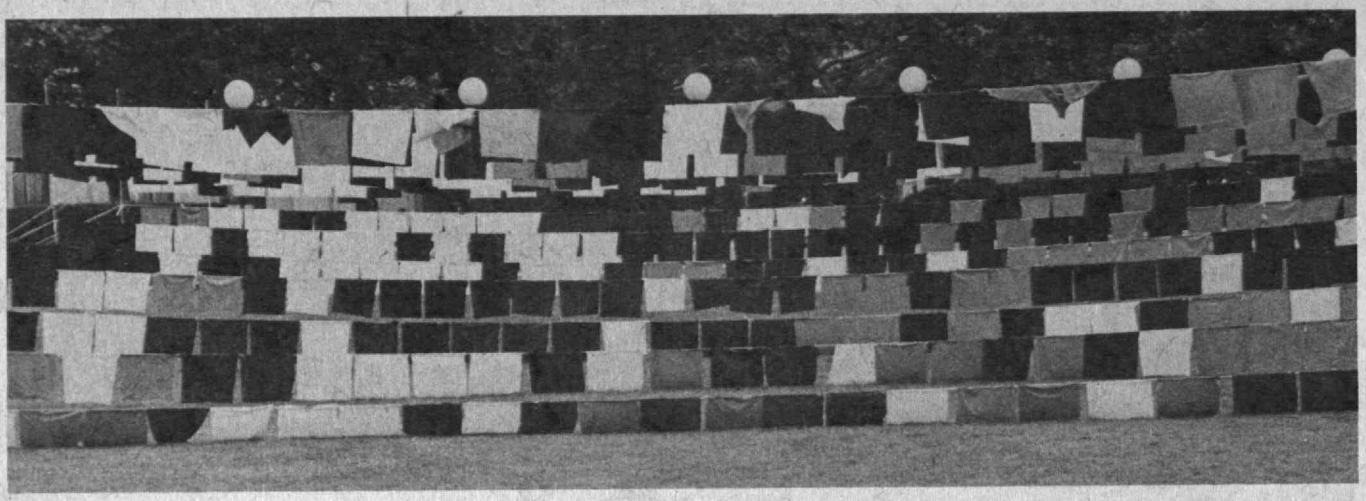


Fourteen tanks of helium — each containing 22 cubic feet of gas — were used to lift an inflated moonlit rainbow of polyethylene tubing and dangling neon rods, unfurled from a huge wooden spool. A shimmering red spectacle, it attracted passers-by and amateur photographers during Arttransition, M.I.T.'s five-day conference on art and technology last fall. The 300-foot long arc over Briggs Field was designed by Otto Peine, Director of M.I.T.'s Center for Advanced Visual Studies, and M.I.T. Research Fellow Alijandro Sina. The 75 neon rods' glow was achieved by a high frequency, high voltage, ultra low power system activated by a standard car battery and spark plug. Winds ranging from the west up to 20 m.p.h. created strobe-like patterns along the length of the rainbow during its two-hour appearance. (Photo above: Calvin Campbell; right: Roger Goldstein, '75)





Can art be a force in the reestablishment of our fragmented communities? It can, said James Ackerman, Professor of Art History, Harvard University, second from left in the panel (above) during Arttransition. Other panelists in the photo are: John Nolan, President, Massachusetts College of Art, Jerome Wiesner, President, M.I.T., Gyorgy Kepes, Founder, Center for Advanced Visual Studies, Roy Lamson, Special Assistant to the President, M.I.T., and Manfred Schneckenburger, Director, Kassel Documenta 6. Concerts, art exhibitions, and events such as Charlotte Moorman's "Concerto for TV Cello and Video Tapes" (above) — she played a plexiglass cello encasing three TV sets — prompted lively discussions. (Photos: Roger Goldstein, '75)



"The elements at work are probability curve and random numbers . . . Colors used and their adjacency are arbitrary," writes the Art Research Center Group of Kansas City, Mo. of their structure outside Kresge during Arttransition. (Photo: R. Goldstein, '75)

self-appointed task is to call our attention to our mistakes."

But if the artist is to be our conscience, he must bridge the communication gap between fundamentally different disciplines. C. P. Snow used the term "different cognitive styles"; and bridging those is precisely the point of the arts in an environment such as M.I.T.

"It happens that nature is logical, and you can go back and make equations. Accordingly, the scientist has an enormous amount of information brought together in his semiconscious. But discovery is an intuitive process; what the scientist does with his information is much akin to other creative processes." These creative processes are fragile; "the artistic temperament is a little flower," said Gyorgy Kepes, founder of the Center for Advanced Visual Studies. "We must find the right water, the right food to make it grow." He defines art as "man's ability to respond to the quality around him, to create a new combination which has validity and meaning not only to the artist, but to the viewer."

Today, says Professor Kepes, we are living in an environment of sensory deprivation so severe as to be "criminal" in its effects. To the artist is the power and duty to change this — because his is an extraordinary ability to feel the world with integrity and sensitivity.

We test intelligence but not happiness or fullness, and in this Dr. Kepes senses great potential for tragedy. The real goal of education should be to develop the ability to live as intensely as a child can live — to have joy.

Professor Roy Lamson, Special Assistant to the President for the Arts at M.I.T., suggests that the artist has grasped these qualities more than most. So, he told "Arttransition," he seeks for M.I.T. a special effort "to understand the artist — his strange area of motivation, his talent." He thinks the artist must have a place to develop his skills, a place where groups of artists work together. And art should not be thought an extracurricular activity. — *M.L.*

Art Is "To Last . . . It Will Stay Forever . . . "

How do artists feel about their work and their goals? Listen to six speakers at "Arttransition," a five-day series of panels, presentations, and audio-visual happenings (*see left*) at M.I.T. this fall:

— *Christo* (His current project is a "Running Fence," 18 feet high and about 24.5 miles long, made of 165,000 yards of heavy white nylon fabric hung from a steel cable strung between 2,270 steel poles. It is to be installed 43 miles north of San Francisco in the fall of 1976.): The most exciting and dynamic part of his work is invisible: during preparation he becomes embroiled in discussions of political, social, and ethical issues, he explained. "My projects involve many people working together; the most important thing is that the work exists and once was there — it will stay forever in our minds." (After four years of preparation, the running fence will exist for two weeks before being removed.)

— *Nancy Holt* (environmentalist, creator of large site works) is "not interested in doing something ephemeral that exists just in a film documenting an event. Her art is made to last. She selects a site which is just right for a piece she wants to build — and buys the land. "I want to go to the far reaches and do work that will restate the environment."

— *Karin Bacon* (celebrationist): Though her festivals are very ephemeral, they have a kind of durability because they can reoccur. Like a ritual, there is strength in repetition, she explained. Her concept is to "animate the total space"; images made by many different people together form a totality; harmony happens among people and between people and outdoor spaces.

— *Otto Piene* (Director of the Center for Advanced Visual Studies at M.I.T.): An educator should try to generate interest in working with the environment instead of in limited space; more artists should work more on a "physical scale." His pieces are large, but their size is relevant. Referring to his balloon at the Prudential Center (*see October/November, 1975, p. 91*), he said, "I go across the river and it already looks very small — from there I can see a huge mass of the city which drowns it out. And if I go up in the air, I can see no art."

— *Rockne Krebs* (environmentalist who works with laser beams of light): Art transcends the apparatus; the goal is the orchestration of art with the landscape, the weather, the trees — anything which comes within the visual field of the viewer.

— *Allan Kaprow* (painter, sculptor, assemblagist, electronic composer): The education of young children is all visually oriented — painting, model-making, clay. But suddenly all this emphasis on conceptual tools is cut off, and children are pushed into textbooks and rote. How to counterbalance this mistake? "Get into Madison Avenue — the most powerful educational force is the mass media. That is where impressions are indelibly formed." Advertising uses enormously sophisticated tools to sell. By contrast, the artist is still in a cottage industry laboring so that a few kindred spirits can rejoice. "We are not more effective because we use old tools." — *M.L.*

"Magnet" School Plan for East Boston; a Computer for Your Income Tax?

Judge W. Arthur Garrity's order seemed as simple as it was logical: let Boston's many excellent colleges and universities go to work with the Boston School Department to create "magnet" schools which would rise above the confusion and ill-will of Boston's year-long struggle over desegregating its public schools. These "magnets," whose excellence would assure good training and attract city-wide attendance, would help accomplish desegregation voluntarily — instead of by force.

Judge Garrity, who presides over the U.S. District Court in Boston, directed the Boston School Department to work with M.I.T. to make East Boston High School and the nearby Barnes Middle School into city-wide "magnet" technical schools by September, 1976 (*see July/August, p. 88*). Wentworth Institute (a two-year post-high-school technical institute) and the Massachusetts Port Authority (which operates Logan International Airport in East Boston) were to be associated in the project.

But the simplicity was an illusion. There is nothing simple about entering a close-knit uneasy community as an externally-imposed expert, and high-school-level technical education is not a simple subject, either.

M.I.T.'s planning began late in the spring, almost immediately after Judge Garrity issued his order. By fall, Institute officials and faculty had held countless meetings with East Boston High School officials, teachers, and students; had begun to analyze high-school-level technical curricula; proposed a $331,000 "transitional planning" grant for M.I.T., Wentworth, and the East Boston schools; and had plans to scan high-school-level technical education throughout the country for proven, existing programs which could be imported as building blocks for new "magnet" activities.

It is a two-track strategy, simultaneously seeking the basis for a wholly new curriculum (a five- to ten-year "absolutely immense" job) and planning innovations which can produce in the short term a program that is "responsible and serious" for as many as 1,000 students who may apply by September, 1976.

Already important steps have been taken:

— Stanley Russell, a science teacher who was formerly Superintendent of Schools in Sharon, Mass., has joined the M.I.T. staff as Director of the Secondary Technical Education Project (see below).

— Eight students from East Boston High School joined the M.I.T.-Wellesley Upward Bound Program for six weeks this summer. They lived with one of their teachers at Wellesley and studied with M.I.T. and Wellesley students as tutors on the M.I.T. campus.

— Two East Boston High School teachers attended a week-long course in digital electronics at the Lowell Institute School in June.

— M.I.T. students, who have for many years conducted Saturday classes for Greater Boston high school students, will make special efforts to serve East Boston.

Walter L. Milne, Special Assistant to the President for Urban Relations, thinks Judge Garrity's an especially difficult challenge. Success depends on finding solutions to three major problems:

— M.I.T.'s own modest capacity, in terms of both people and money, to help. The "magnet" school concept seems to contain "an inexhaustible vacuum for money," says Barbara S. Nelson, Assistant to the President and Chancellor. M.I.T. cannot make substantial financial contributions, she says, and other funding is unpredictable.

— The capacity of the Boston school system to carry on, manage, and finance a sophisticated "magnet" program in technical education even if one can be devised.

— The capacity of the local market (Greater Boston) to provide good job opportunities for graduates of such a program.

Professor Philip Morrison, who was a lively participant in a recent discussion of the "magnet" school concept, adds a fourth problem: How to gain the interest and confidence of the community, many of whose children will be displaced into other Boston schools by the "magnet" school in East Boston? His answer: Appeal to their curiosity; put a computer terminal attached to an M.I.T. computer in a storefront, and let people come in and get acquainted. Maybe even use it to figure their income taxes. □

Stanley Russell Runs the "Magnet" Project

M.I.T.'s "high-risk venture" — helping to create a city-wide "magnet" technical school at East Boston High School within a year (*see right*) — will be the responsibility of Stanley Russell, named late in the fall to be Director of the Secondary Technical Education Project (STEP).

Dr. Russell was chosen after a nationwide search by M.I.T. and its project partner, Wentworth Institute. He was for five years a science teacher at Shady Hill School, Cambridge; for three years a science and mathematics teacher and three years guidance counselor at Weeks Junior High School, Newton; for seven years Assistant to the Superintendent of the Newton Public Schools (when he was also a consultant to the Ford Foundation and an Associate at the Harvard Graduate School of Education); and for six years Superintendent of Schools in Sharon, Mass.

Dr. Russell's will be no simple task. Nina McCain of the *Boston Globe* calls the M.I.T.-Wentworth-East Boston collaboration "one of the most ambitious and most expensive" of the partnerships between colleges and schools ordered by U.S. District Judge W. Arthur Garrity, Jr., last spring. "A mind-boggling task," she says.

Walter L. Milne, Special Assistant to the President of M.I.T. for Urban Relations, agrees, but he is cautiously confident: "If we didn't feel we could do a serious piece of work, we wouldn't have attempted it," he told Ms. McCain. Indeed, he said at an M.I.T. meeting during the fall, "we have an opportunity to put in place a new model of a public technical high school . . . a prime example of what secondary technical education could be for the 1980s." And he hopes that the whole community will find that — as he does — "an engaging, appealing vision."

Speaking to the faculty in the fall, President Jerome B. Wiesner called M.I.T.'s assignment "a task on which we have some competence but little experience." But Dr. Wiesner thinks it is "an issue very close to the basic intellectual concerns of the Institute . . . an opportunity with considerable learning potential for faculty and students"; and so he hopes that Dr. Russell and STEP can capture the interest of significant numbers of both students and faculty.

Dr. Russell studied biology at Brooklyn College (A.B. 1947) and science teaching at Teachers College of Columbia University (M.A. 1948). His doctorate in educational administration is from Harvard (Ed.D. 1969).

Students

Teams Capture Titles

Four M.I.T. varsity teams — two women's, two men's — captured sports headlines during the fall season. It was one of the best varsity seasons in recent history.

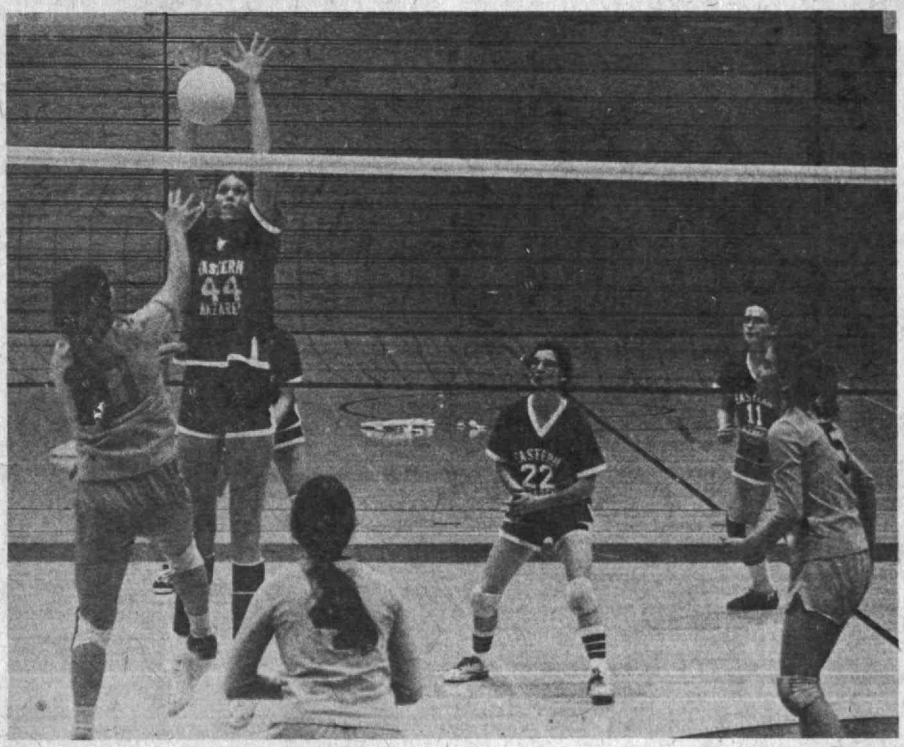
The women's volleyball team, competing as a varsity sport for the first time, is Division II Massachusetts State Champion. On the way to the top in championships played at Boston University, the women won the Metropolitan Women's Intercollegiate Athletic Council volleyball title and took games from Southeastern Massachusetts, Rhode Island, Northeastern, Regis, and Boston State; there were 15 wins in the 16-game regular season, dimmed only when a coveted bid to the Eastern volleyball championships failed to materialize.

As the season opened David A. Dobos, '78, predicted that it could be "the most successful in history" for M.I.T. cross-country. He was right. Dave's team colleague, Frank Richardson, '78, finished fifth in the Division III national championships in November, and M.I.T. was 18th in the competition. A good end to a season that included an 8-4 record in dual meets and sixth place in the Eastern championships. Richardson's best time over the five-mile Franklin Park course was 24:30, a new course record, against Boston College and Lowell; his time in the nationals was 24:45.

As the fall sailing season unfolded, the men's team brought home third place in the Fowle Trophy, second in the Franklin J. Lane trophy, first in the Jack Wood Trophy, first in the Oberg Trophy, second in the Schell Trophy for the New England fall championship, and fourth in the Fiske-Harriman-Sleigh Trophy for the Atlantic Coast championship. *The Tech* said the team would probably be ranked 12th in the nation.

The women's record in sailing included sixth in the Wick Invitational, second in the President's Trophy, first in the Man Lab Trophy, second in the Yale Intersectional 420 Regatta, and third in the Victorian Coffee Urn Regatta (vs. ten New England schools and won by Radcliffe and Smith). M.I.T. women took five of the top ten places in the New England Single-Handed Championships, in which Allana Connors, '78, was second.

Everybody rows in the "Head of the Charles" Regatta: this fall 2,870 competitors from 134 colleges, schools, and clubs were in 683 boats, according to the *Boston Globe*'s count. There were 22 entries from M.I.T., and when it was all over the Engineers were third overall in team rankings. The best finish by an M.I.T. entry was fifth — the varsity lightweights. Professor Gail Pierson (economics) was fifth in the women's singles, Professor Hartley Rogers, Jr., (Associate Provost) was eighth in the veteran singles, the women's fours finished ninth, and the elite fours finished eighth. □



Highlights of the fall sports season, as captured by The Tech*'s photographers: a momentary soccer duel between Steven Bernays (dark shirt) and his Boston College opponent (M.I.T. won, 1-0) . . . Gregory C. Coutts, '77 (second from left), scrambling for the ball during a 7-6 rugby victory over Boston College . . . Frank Richardson, '77, running to fifth place in the N.C.A.A. Division III Cross-Country Championships . . . and Lisa Jablonski, '77 (number 10), in the finals of the Division II Massachusetts Volleyball Championships. (Photos: David A. Schaller, '77, Richard F. Reihl, '77, and John A. Hopper, '76, from* The Tech*)*

While not presiding over "The Ghetto" (see below), James E. Clark, '76, finds time to be Co-Chairman of the M.I.T. Black Student Union. In the picture, he and John W. Arnett, III, '76, (right), Co-Chairman, offer Albert G. Hill a plaque of appreciation: Dr. Hill, who retired last June as Vice President for Research, is the sponsor of a prize for the black student "who shows the most progress in the sophomore year."

Participation Radio: "The Ghetto" on WTBS

"The Ghetto" — five and one-half years old this fall is the unlikely jewel in the crown of WTBS, the student-operated F.M. station at M.I.T. It's soul music, participation radio, is a link among members of a community whose links are few and cherished. But it's nothing that fits most preconceptions of what might happen when M.I.T. goes on the air.

From midnight to 3 a.m. every morning the listener is like one of the family, able to participate and aware of who else is listening. "We try not to make ourselves so far removed from our listeners that we assume we know what they want to hear," explained James Clark, '76, former program director and general manager of WTBS, involved in "The Ghetto" since its beginning.

He recalls how the idea started: "Some members of the Black Student Union felt it was a good idea to have a program of evening soul music on WTBS since the only other major source of soul music, WILD, signed off at sunset. None of them had ever seen the inside of a radio station, but they started learning." (Before anyone operates anything at WTBS, he must be trained to pass a WTBS engineering test.) "The training classes are now being taught by some of the same people that showed up with me over five years ago," he added.

"The Ghetto" started to catch on when disc jockeys began putting telephone callers on the air live. Most other stations at the time prerecorded such calls. "We asked people to 'check in' if they were listening, and they could mention their names over the air. We got thousands of calls — nonstop."

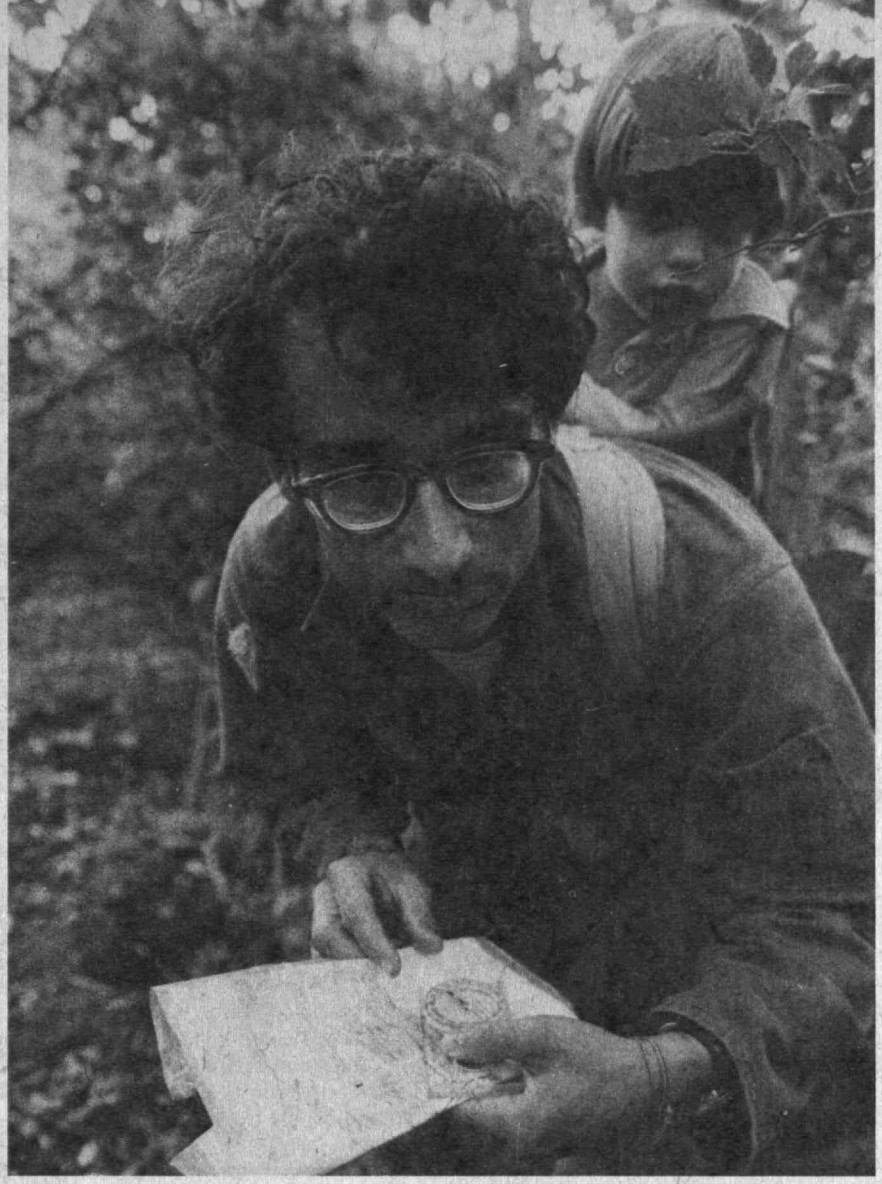
Mr. Clark described other gimmicks: "We would answer requests to dedicate a record to someone who was listening. On 'Instant Request,' the disc jockey would try to have a record on the air within 15 seconds of a live request. One night we were averaging below five seconds," he said with relish. "Project Concern" was prompted by the news of two black students killed at Southern University in Louisiana. Someone called in to suggest that if people were concerned, they could pledge money through "The Ghetto." "We immediately put "The Ghetto" on the air for a week in the daytime," explained Mr. Clark, "and received pledges of $4,000 for Southern University."

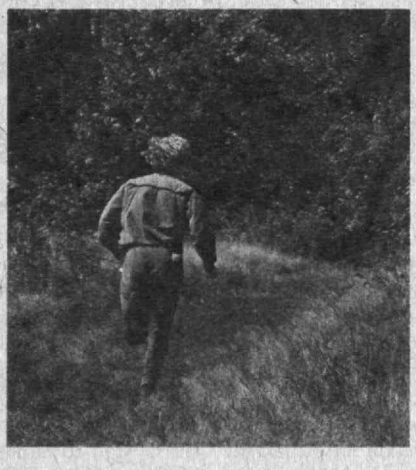
The staff became involved in off-the-air projects, too. For "Party of the Year" they rented telephone audio lines and transmitted music to five locations simultaneously. The price of admission was canned goods, which were donated to the Kwanza Prison Program. And one of the few concerts held at M.I.T. that didn't lose money was organized by "The Ghetto" staff.

As the program's popularity increased (it reaches the metropolitan Boston community out to about Route 128) commercial and non-commercial stations started competing with soul music programs at similar times — some in stereo with thousands of times more power. One such station is at 88.9 F.M. "Unless a listener always leaves his radio dial on 88.1," said Mr. Clark, "he will encounter WERS first. That puts WTBS in a rotten position — yet folks do find their way past and come on down." (WTBS has an application to the F.C.C. for higher power which will allow them to "more effectively serve the community.")

Mr. Clark feels that "WTBS is one of the greatest public relations sources M.I.T. has, for white audiences as well as black." He says the equipment needs to be updated; M.I.T. does not allot as much money as he thinks necessary; and he would like to see alumni contribute directly to WTBS. "But even if funds don't come," Mr. Clark explained, "our aim is innovative radio programming for our community of listeners."

How does one become involved in WTBS? Participants are not exclusively M.I.T. students. "People essentially seek out WTBS, not vice versa," explained Dave Gifford, '76, WTBS General Manager. "To a new person, access to the inside may look like a brick wall; you get the run-around. If you're shuffled around for 15 minutes in a real office you may get frustrated; at WTBS it might be three weeks before the person you need to talk to appears." The reason: "no one is getting paid." But the work gets done — the busy schedule of programs is diverse, even though, many of the hours on the air take two to three hours of production effort. — *M.L.*





Orienteering: give contestants (singles, couples, families) a map of a piece of New England terrain – woods, swamps, moraines, and kettle holes — on which are marked a starting point (S), way stations (A, B, C, D, . . .), and a final destination (X). Turn them loose at S with instructions to reach X via A, B, C, D, . . . as quickly as possible. As practiced by the M.I.T. Outing Club, "it's a combination of cross-country running and accurate reading of a map and compass," says Robert W. Milne, '77, Outing Club President. "A prerequisite is that you are sensitive to your environment." (Photos: Owen D. Franken, '68, for Technology Review*)*

M.I.T. Student Elected to Cambridge City Council

Councillor David E. Clem

"After I was accepted at M.I.T., my wife and I came to Cambridge to find an apartment. We couldn't believe the high rents and began to think of buying a house. We found one on Western Ave. that we could afford. It was a wreck — a six room house with 26 people living in it as a commune. The group was paying $400/month while the house next door, rented to a family, only cost $150/month. We discovered one reason for the tight housing market.

"We bought the house and moved in all our belongings, but we had to leave town for a few days. I asked the Cambridge Police Dept., located 300 yards up the street, to look after the house while we were away. Ten days later we returned on the weekend only to find five squatters living in our house. That was our first lesson with the Cambridge police.

"And then, at 4:00 a.m. on Monday morning, we discovered that Western Ave. was a truck route, 1800 heavy tractor trailer trucks every day."

It was then that David Clem, M.I.T. graduate student in urban studies and planning, became involved in politics. He formed H.A.L.T. (Humans Against Loud Trucks) which succeeded in having trucks rerouted off residential streets at night. His field work as part of courses in city planning gave him broader exposure to the Cambridge political scene. Now he has waged a successful political campaign and — to most observers' surprise — is a member of the Cambridge City Council. (Not since 1961 has a newcomer beat an incumbent and Clem is the youngest Councillor in the history of the city.)

His views on some issues involving M.I.T.:

Although their non-profit status exempts them from normal real estate taxes, Mr. Clem feels that M.I.T. and Harvard contribute an inadequate sum in lieu of property taxes, considering the value of their property. Indeed, half of all the land area in Cambridge is tax-exempt, and Mr. Clem finds this is a serious problem for a community that must generate a large percentage of its revenue by property tax. While M.I.T. and Harvard only occupy eight per cent of the land, they control 26 per cent of the value.

"I think it's a more serious waste that Institute expertise is not shared more with the community," thinks Mr. Clem. There is intense resentment of the universities in a large segment of Cambridge, especially working families in the eastern half of the city. They see M.I.T. and Harvard as big business, big power — an octopus acquiring real estate, pushing up land value, and driving out residents who don't have entry into the system. ("But I can see the other side," he said, "paranoia on the part of the Institute about being involved. Every time the Institute gets involved it gets burned.")

Mr. Clem also feels there is a lack of significant commitment on M.I.T.'s part to the larger community. "M.I.T. draws a line between itself and the community; the Institute sees itself not as a subset of the whole, but as a mini-universe, operating on its own." But he can see a reason: "Cambridge is so volatile politically. We invest lots of resources one year, then a new regime takes over and it's all swept away." A closer relationship between M.I.T. and Cambridge is high on his list of priorities as a freshman City Councillor.

Mr. Clem feels that the redevelopment of the Kendall Square area (where controversy centers on how publicly-owned land will be developed) should be controlled by the public sector for the general public good. He thinks M.I.T. has unfairly tried to utilize the public subsidy available to redevelopment to force a plan that will make Kendall Square complement their East Campus. The best possible solution for M.I.T. is not necessarily the best for the city at large. He wants a reasonable compromise, and he thinks that's possible. He suggests that a non-profit group could be formed — separate from M.I.T. — with directors from M.I.T., the city, and the neighborhoods that would operate under a constitution, with veto power over university plans for expansion, and a staff to implement the goals agreed to.

Only a few of the thousands of students in Cambridge are registered to vote. They simply don't get involved because they don't think of Cambridge as home. But this is an easy excuse, says Mr. Clem. A student spending four years here is not a transient — the average person in the U.S. moves every five years. It was a fight to gain the right for students to vote, he says, and now they are not living up to that responsibility. — *M.L.*

Alumni

Must Public Good vs. Corporate Good Pit the Manager Against his Conscience?

If your firm can make money for its stockholders by machining parts for "Saturday-night specials" but you are convinced that social good would be best served by the extirpation of hand guns, what as a manager should be your decision?

That's a simple — indeed, elementary — example of a broad class of new problems which are now a primary lexicon of management — an issue which Louis L. Banks calls "productionism" and which he thinks will soon enough take the place of "consumerism" in the U.S.

"The Management of Change" (the topic for the triennial seminar/reunion of Master's graduates of the Sloan School of Management this fall) is usually taken to mean the tough question of how to keep a company abreast of new technology. Not in the last quarter of the 20th century. The crucial changes to which corporate management must now respond are social, cultural, and economic — hardly technological at all . . . environmental integrity, affirmative action, women's rights, consumer welfare, the health and safety of workers, urban problems, ethics and aesthetics, unemployment and poverty.

And when company executives finally begin to work on these problems, they will begin by catching up with sins of at least a quarter-century of neglect. Mr. Banks, a director of Time, Inc., who is Visiting Ford Foundation Professor at Harvard Business School this year, told more than 300 Course XV alumni: society today is increasingly imposing its ethics and values on modern corporations. The result is a new set of questions and challenges for managers, of which these are but the tip of the iceberg:

— Can we predict the effects of decisions on social and ethical issues, as we have heretofore sought to predict the effects of more conventional management decisions, before we impose them?

— Can the nation help management in the search for "a true business ethic"? ("It isn't enough to just keep kicking us in the pants," said Mr. Banks, in the context of remarks about the business press.)

— Can research and development change its criteria so that new products are evaluated on the basis of their potential positive social value as well as financial values for the company?

— What can be done to assure the achievement of "large breakthrough projects" which promise "conceptual solutions to social problems" but little profit for corporate sponsors? A collaboration between business, government, and academe?

Roadblocks to "Productionism"

The problem, thinks William J. McCune, Jr., '37, President and Chief Operating Officer of Polaroid Corp., is this: technological change has direct effects on the firm and its products. An effective manager has within his own resources the strategies needed to move his company from new science to new products.

Now it's different. To any one manager social goals appear indistinct and even abstract, their achievement far beyond a single authority. Another problem, too: "The less direct the impact of a solution on a company, the less motivation to the company's management to achieve a solution," said Mr. McCune.

Even something as simple as an accounting convention can be a roadblock on the way to social reform. The example cited by Clay T. Whitehead, '60, Fellow in the M.I.T. Center for International Studies who was formerly Director of the U.S. Office of Telecommunications Policy: it's normal to consider research and development as investment in technology, but new employee benefits are always considered costs, never investments.

A different reasoning to the same conclusion from John S. Reed, '61, Executive Vice President of the First National City Bank: managers find social change more difficult to deal with than technological change because it occurs more slowly, because it affects personal values and lives, involving us in issues "with which we are not neutral and problems with which we're not comfortable." Can management innovate in the social arena? Mr. Reed thinks not: his advice is to expect only that managers be responsive to social change, not that they should power it.

If not from management, whence the power for social change? From government, said Mr. Whitehead — but with caution. We are correct to expect government to "impose systemic change" when needed to modify or speed the evolutionary changes which are normal in any society. But government is now going too far, entering areas of "active management control" — energy conservation, employment opportunities, job safety . . . "an excessive drift of power to government from the private sector." And because government does not have the responsibility of ownership, thinks Mr. Whitehead, this change is leading "toward a situation which is neither stable nor manageable," a trend toward having "the entire private sector managed through the public sector."

Distributing Costs and Responsibilities

From afternoon discussion panels came a series of questions and observations:

— Social goals may lead an organization to problems with pluralism — too many individual options fitting employees to their special needs, for example. How many such pluralistic responses to changing values can a corporation tolerate without failure from disorganization, even chaos, and high costs?

— What of the manager who finds himself faced with a fundamental conflict between the public good and the long-term continued profitability of his firm? Let him look again, said Arnold E. Amstutz, '58, Senior Lecturer in the Sloan School; he will almost surely be able to devise a plan which at once impacts favorably on his firm's long-term profitability and on the public good.

— Too many managers have "tunnel vision" — an inadequate understanding of how to get things done, said Richard S. Morse, '33, President of the M.I.T. Development Foundation, Inc. The first stage should be to bring teachers of management to the full understanding of the issues wrapped up in "productionism" that they already have of

traditional issues in profitable management. — If we increase the complexity of the goals which a manager must fulfill, we accordingly enlarge his responsibilities and increase his corporation's risk. Problem: how are the special risks involved in corporate responses to societal issues to be distributed, and who is to meet the inevitable costs? This is especially a problem because we know so little about the consequences to the corporation of whatever responses it can make to social concerns.

Management: the Same in Every Field

Pondering the implications of all this, an alumnus asked William F. Pounds, Dean of the Sloan School: if the setting and problems of management are so different now from when I studied at the School, what are you doing to prepare today's students for all these new dimensions of their jobs? What have you left out of the curriculum, to make room for all this new material?

Nothing, said Dean Pounds; it's not quite like that.

When you went to school, Dean Pounds told his questioner, you studied a curriculum that was generalized to be useful for managers in many different modes and sectors. It was then — and it is now — a question not of giving students answers to every foreseeable question but a framework for their knowledge — the ability to work constructively by learning, when the time comes, the details of all the problems which might later confront them.

For example, said Dean Pounds, the School now enrolls students interested in working in both private and public sectors, and the School's curricula are just as useful for those who want to manage health care, urban government, even management itself for those who plan traditional careers in the private sector. "Health people do not want to be different," said Dean Pounds, and the Sloan School agrees. "Our growing role in public sector management problems has changed our perspective but not our coverage," he said. — *J.M.*

Alfred P. Sloan, Jr.: A Humanistic Manager in a Simpler Day

In 34 years as the leader and builder of General Motors Corp., the late Alfred P. Sloan, Jr., '95, maintained a special interest in the philosophy and professional responsibility of management. Was it literally true in that era that "what's good for General Motors is good for America"? Perhaps; and if so, that was because of the course which Mr. Sloan set for that corporation.

Out of this background came naturally Mr. Sloan's interest in the course in business and engineering administration at his alma mater; he was convinced that science should become more a part of management, management more of a science. Hence his support — at least $20 million — which transformed that course into M.I.T.'s fifth school: the Alfred P. Sloan School of Management.

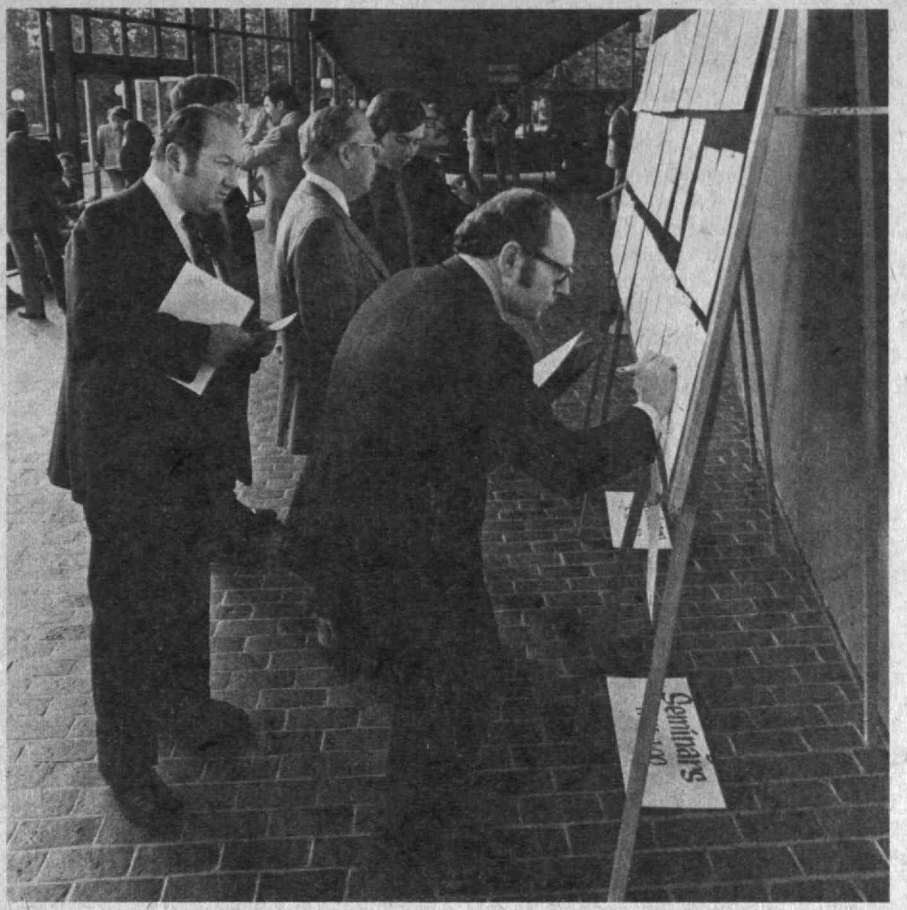
And when he finally retired from an active career with General Motors in 1956, Mr. Sloan made clear in his autobiography that he saw no dichotomy between his past and his plans for his future. He wanted simply to continue to devote his productivity "to the general good of society" through the Sloan Foundation and through his own personal benefactions.

James R. Killian, Jr., '26, who was Vice President, President, and finally Chairman of the Corporation during the years of Mr. Sloan's greatest interest and benefactions to the Institute, recalled this early example of "productionism" for alumni of the Sloan School of Management last fall during their triennial convocation: it was in the year of Mr. Sloan's 100th birthday.

In all, Mr. Sloan's beliefs in "technology, quality, and management" led him to make gifts totaling just under $57 million to M.I.T. "There is no comparable record of a single benefactor to a single institution in the U.S.," thinks Dr. Killian.

Dr. Killian credits the traditional concern for public issues at General Motors by Mr. Sloan with a part in the establishment by G.M.'s Board of Directors in the late 1960s of its Committee on Public Policy, of which Dr. Killian was for some years Chairman. The Committee's agenda, said Dr. Killian, included at least a score of issues reflecting the role of the corporation in responding to social problems: minority rights; consumer interests; corporate policy in relation to prices, profits, and ethics; responsibilities in ecology; activities in research and engineering.

The Committee's deliberations, recalled Dr. Killian, "represented important, thoughtful criticism of corporate policy. . . . A unique, first-time committee," Dr. Killian called it, "one of the most stimulating experiences I have had in serving the corporate community of the U.S." □



Nostalgia and education were the twin appeals which brought some 300 alumni of the Sloan School of Management back to Cambridge this fall for lectures, discussions, and seminars; and perhaps the hardest problem of the two-day convocation was to select from the scores of available opportunities (left). Pictures on the opposite page show (top to bottom) James R. Killian, Jr., '26, speaking at the convocation banquet . . . Arnold E. Amstutz, '58, as a discussion leader . . . Co-chairmen Professor Charles A. Myers (left) and Randall S. Robinson, '55. (Photos: Bradford Herzog)

People

Arts Council Honors Ferré, White, Liepmann

A big day for the Council for the Arts at M.I.T. at its annual meeting on October 24:
— Luis A. Ferré, '24, was named Chairman of the Council, succeeding its charter Chairman, Paul Tishman, '24.
— Minor White, Professor of Photography, Emeritus, who is now Senior Lecturer in the Department of Architecture, was named first Fellow of the Council.
— Klaus Liepmann, Professor of Music, Emeritus, received the second annual Eugene McDermott Award as "the father of music at M.I.T."

Mr. Tishman has been Chairman of the Council since its inception in 1971, and he's been looking for a successor for more than a year, he said. Now Mr. Ferré, having fulfilled his commitment as President of the Alumni Association is available, and Mr. Tishman lost no time in enlisting him.

Mr. Ferré, who could not be at the meeting, said in a telegram that "nothing could give me greater pleasure than to help M.I.T. in broadening the education of its students, to give them a fuller grasp of the arts and humanities as an essential part of their training to become competent scientists and engineers with the sensitivity and understanding that is necessary to make them better citizens and happier human beings."

As Fellow of the Council, Professor White will deliver a public lecture in the spring. It's a new program "to further education in the arts at M.I.T.," says Roy Lamson, Special Assistant to the President for the Arts.

The McDermott Award, "for major contributions to the arts as a means of human fulfillment," went to Professor Liepmann with a citation that said, "The measure of this man is no less than melody itself. Music is not only his profession but his metaphor. . . . His ears have long been attuned to the perrennial song of youth, and he has constantly raised his voice to remind us that students want beauty as well as apprenticeship. And so his mind has been a metronome, keeping us in time with our time." □

Mrs. Jacques Lipchitz (second from the right) was honored during the 1975 meeting of the Council for the Arts at M.I.T. when members visited Hayden Library courtyard. Five Jacques Lipchitz sculptures are on display there, on loan to M.I.T. through the generosity of Mrs. Lipchitz. Left to right, front row, are Paul Tishman, '24, retiring Chairman of the Council; Professor Wayne V. Andersen, Chairman of the Committee on the Visual Arts; Mitchell Silverstein, '48, a member of the Council; President Jerome B. Wiesner; Mrs. Lipchitz; and Mrs. Tishman.

Individuals Noteworthy

Kudos: Honors, Awards, Citations

To **S. Donald Stookey,** Sc.D. '40, Director of Fundamental Chemical Research at Corning Glass Works, the 1975 Phoenix Award of the glass industry sponsored by *Glass Industry Magazine* . . . to **Jacob P. Den Hartog,** Professor Emeritus of Mechanical Engineering at M.I.T., the Trent-Crede Medal of the Acoustical Society of America "for his contributions to the field of shock and vibration as a practicing engineer, author, and teacher." Professor Den Hartog also received an honorary doctor of science degree from the University of Newcastle-on-Tyne, England . . . to **Roger G. Burns,** Professor of Mineralogy and Geochemistry at M.I.T., the Mineralogical Society of America Award for 1975 for his contribution to mineralogical applications of crystal field theory.

To **Charles J. McMahon, Jr.,** Sc.D. '63,

Professor of Metallurgy and Materials Science at the University of Pennsylvania, the Mathewson Gold Medal Award of the Metallurgical Society of the American Institute of Mining, Metallurgical, and Petroleum Engineers, and corecipient of the Henry Marion Howe Medal of the American Society for Metals . . . to **Lester Machta,** Sc.D. '48, Director of the National Oceanic and Atmospheric Administration's Air Resources Laboratory in Silver Spring, Md., the $1,000 1975 N.O.A.A. Award for Scientific Research and Achievement . . . to **Harry R. Glahn,** S.M. '58, Deputy Director of the Techniques Development Laboratory of the National Weather Service, the annual award for Engineering and Applications Development of the N.O.A.A.

To **Alan S. Willsky,** '69, Assistant Professor of Electrical Engineering at M.I.T., the 12th Donald P. Eckman Award of the American Automatic Control Council . . . to **Harold Locke Hazen,** '24, Dean Emeritus of the M.I.T. Graduate School, the 1975 L.E. Grinter Distinguished Service Award of the Engineer's Council for Professional Development . . . to **Phyllis A. Wallace,** Professor of Management at M.I.T., the Eartha M. White award of the National Business League "for exemplary dedication to the cause of minority entrepreneurship and management education" . . . to **Hoyt C. Hottel,** '24, Professor Emeritus of Chemical Engineering at M.I.T., the 1975 Royal Society Esso Award for the Conservation of Energy for his contribution to the science and technology of solar energy collection.

To **Ronald L. Bagley,** '69, the U.S. Air Force Commendation Medal . . . to **Andrew J. Viterbi,** '56, Executive Vice President of LINKABIT Corp., San Diego, Calif., the 1975 Christopher Columbus International Communications Award given annually by the city of Genoa, Italy . . . to **Tarek S. Aziz,** Sc.D. '74, the $300 Fourth Award in graduate student competition in the 1975 Engineering Student Design Competition sponsored by the James F. Lincoln Arc Welding Foundation of Cleveland, Ohio . . . **J. Herbert Hollomon,** '40, Professor of Engineering and Director of the Center for Policy Alternatives at M.I.T., has been named to the recently established Japan Steel Industry Professorship at M.I.T. made possible by a $1 million gift from the Japan Iron and Steel Federation.

Robert B. Semple, '32, Chairman of the Board of B.A.S.F. Wyandotte Corp., Wyandotte, Mich., has been elected a Fellow of the American Institute of Chemical Engineers . . . **Martin C. Jischke,** '64, Associate Professor of Aerospace, Mechanical, and Nuclear Engineering at the University of Oklahoma was appointed by the President to a 1975-76 White House Fellow.

Counselors: Officers, Directors, Advisors

Norman A. Jacobs, S.M. '59, President of Amicon Corp., elected President of the Licensing Executives Society, Inc. . . . **Stephen A. Kliment,** '53, Architect and Editorial Consultant, to a second four-year term as Chairman of the Advisory Council of the School of Architecture and Urban Planning at Princeton University . . . **H. Stanley Palmer,** '48, Plant Engineer at Colby College, to the Energy Conservation Committee of the Association of Physical Plant Administrators of Universities and Colleges . . . **Julius S. Levine,** M.C.P. '60, Executive Vice President of Gladstone Associates, to the Board of Governors of the American Institute of Planners.

Thomas F. Jones, Sc.D. '40, Vice President for Research at M.I.T., and **George F. Schlaudecker,** S.M. '39, Group Vice President for Chemicals at the Sherwin-Williams Co., Cleveland, have been elected Directors of Industrial Nucleonics Corp., Columbus, Ohio . . . **Charles B. Henderson,** S.M. '42, Director of the Research and Technology Division at Atlantic Research Corp., Alexandria, Va., to Vice President of the Corporation . . . **Richard S. Morse,** '33, President of the M.I.T. Development Foundation, Inc., named by President Ford to the general advisory committee of the Energy Research and Development Administration.

Albert E. Paladino, Sc.D. '62, to the Materials Program in the Office of Technology Assessment of the U.S. Congress . . . **Peter Benjamin,** S.M. '66, to Director of the Division of Technical Coordination and Support in the Office of Capital Assistance of the U.S. Department of Transportation's Urban Mass Transportation Administration.

Walter L. Milne, Assistant to the Chairman of the M.I.T. Corporation and Special Assistant to the M.I.T. President for Urban Relations, to the Community District Advisory Council for Boston Public School District 9 . . . **Rogers B. Finch,** '41, Executive Director and Secretary of the American Society of Mechanical Engineers, to the Board of Directors of the American Society of Association Executives . . . **John S. Reed,** '61, Executive Vice President of First National City Bank, to the Board of Directors of Philip Morris, Inc. . . . **Henry D. Jacoby,** Professor of Management at M.I.T., to the Committee on Future Energy Prospects of the National Petroleum Council.

Appointments: Rising in the World of Business

Andrew F. Corry, '44, to Vice President of Electric for Boston Edison Co. . . . **D. William Lee,** Sc.D. '58, Vice President of Arthur D. Little, Inc. . . . **S. Bruce Smart, Jr.,** S.M. '47, President and Chief Operating Officer of Continental Can Co. . . . **Dedy R. Saban,** '53, Senior Vice President and Director of International Operations of Cramer Electronics, Inc. . . . **Clyde N. Baker,** '52, Executive Vice Pr3siden5 of Soil Testing Services, Inc., Northbrook, Ill. . . . **Nicholas D. DePasquale,** '71, Vice President for Tactical Weapons Systems at the Orlando, Fla. division of Martin Marietta Aerospace . . . **Franz H. Tyaack,** '51, Vice President of Westinghouse Electric Corp.

Items of Interest

Phyllis A. Wallace, Professor of Management at M.I.T., edited the recently published *Equal Employment Opportunity and the A.T. & T. Case* . . . **Myron Tribus,** Director of the Center for Advance Engineering Studies at M.I.T., presented the keynote address at the September, 1975 Conference on Productivity Improvement in the Service Sector of the National Economy . . . **Bernard T. Feld,** Professor of Physics at M.I.T., has been named editor-in-chief of the *Bulletin of the Atomic Scientists* . . . **Myron K. Cox,** S.M. '57, has been given a 1975-76 research grant by the College of Business and Administration at Wright State University in Dayton, Ohio.

Appointments in Academe

Donald A. Martin, '62, Professor at the Rockefeller University . . . **Lynwood Bryant,** Professor Emeritus of History at M.I.T. and former director of the M.I.T. Press, Senior Resident Scholar at the Eleutherian Mills-Hagley Foundation and a member of the History Department at the University of Delaware . . . **Robert G. Dean,** Sc.D. '59, Unidel Professor of Civil Engineering and Marine Studies at the University of Delaware . . . **Gus Solomons, Jr.,** '61, Artist-in-Residence in Dance at Denison University . . . **June R. Scott,** Ph.D. '65, Associate Professor of Microbiology at Emory University . . . **Perry L. McCarty,** Sc.D. '59, Silas H. Palmer Professor of Civil Engineering at Stanford University. □

Norman Levinson, 1912-1975: "First Magnitude" Mathematician

N. Levinson

Norman Levinson, '33, a distinguished mathematician who was Institute Professor and Professor of Mathematics at M.I.T. and had served on the Institute faculty for 38 years, died at Massachusetts General Hospital on October 10, 1975, after a long illness. He was 63.

Professor Kenneth Hoffman, Head of the Mathematics Department, described Professor Levinson as "a mathematician of the first magnitude, a scholar whose dedication to excellence has left its mark on all of us." President Jerome B. Wiesner cited "his scholarly brilliance, warm human understanding, and devotion to the Institute."

Only a year before his death Professor Levinson completed a comprehensive manuscript of mathematical analysis setting forth what proved to be the strongest result yet known in the direction of the so-called Riemann hypothesis, one of the most famous, important, and challenging unsolved problems in mathematics. Earlier he had worked with geologists on the M.I.T. faculty to apply mathematical principles developed by the late Norbert Wiener to seismic analysis.

Professor Levinson came to M.I.T. as an undergraduate from Lynn, Mass., and he spent his entire professional career at the Institute after receiving Master's (1934) and Doctor's (1935) degrees here. He joined the teaching staff in 1937 and the faculty in 1939, and from 1968 to 1971 he was Head of the Department of Mathematics.

Professor Levinson held the Bocher Memorial Prize of the American Mathematical Society (1953) for work on differential equations and the Chauvenet Prize of the American Mathematical Association (1970), and he had held fellowships for work at Cambridge University (1934-35), the Institute for Advanced Study and Princeton University (1935-37), the University of Copenhagen (1948), and the University of Tel Aviv (1967). □

Charles E. Smith, 1877-1975 Engineer, Alumni President

C. E. Smith

Charles E. Smith, '00, who was President of the M.I.T. Alumni Association in 1934-35 and a member of the M.I.T. Corporation from 1934 to 1940, died in New Haven, Conn., on September 21, 1975. He was 98.

Mr. Smith studied civil engineering at M.I.T., and he made a distinguished career in that profession, working chiefly for the

Missouri Pacific Railroad, as a consulting engineer in St. Louis, and for the New Haven Railroad, of which he was Vice President from 1928 until retiring in 1949. Beginning in 1907 he was in charge of the design, construction, maintenance, and safety of all bridges on the Missouri Pacific Railroad. As a consulting engineer in St. Louis for 12 years, he was in charge of planning, designing, and building of markets, auditoriums, and transport facilities in the many midwestern states. Finally, in 1928 Mr. Smith returned to New England (he was a native of Somerville) to become Vice President of the New Haven, where he was Assistant to the President and in charge of purchases, the New England Transportation Co., the County Transportation Co., and the New England Steamship Co.

Mr. Smith was the first Alumni Association President to be an ex-officio member of the Corporation; he was a long-time member of the Alumni Council and while a member of the Corporation served as Chairman of the Visiting Committee to the Department of Civil and Sanitary Engineering. During Mr. Smith's leadership and largely at his instigation that annual Alumni Days were substituted for the "All-Tech Reunions" previously conducted every five years. □

Douglas P. Adams, 1908-1975: Nomography and Bostonia

Douglas P. Adams, Professor Emeritus of Mechanical Engineering whose avocational interest in the history of Boston was almost as strong as his professional interest in engineering design, died on October 25 of a heart attack at his home in Charlestown, Mass. He was 67.

Professor Adams studied mathematics (B.S. 1930, M.A. 1933) and law (J.D. 1937) at Harvard, and he taught at M.I.T. for 35 years until his retirement in 1974. His special interest was the use of computers in various aspects of engineering design — nomography, kinematics, and other forms of analysis. He had also studied computer regulation of traffic flow, stereo-electronic recording of surfaces for criminological purposes, and the use of computers for analyzing piping and circuitry in building design.

Even while teaching at M.I.T. Professor Adams had been a member of 16 local historical societies and served five of them as President; he was keenly interested in all aspects of the history of the Greater Boston area, and many undergraduates remember his enthusiastic leadership of an undergraduate seminar on "The Birth and Care of a City."

As a member of the Massachusetts Bicentennial Commission, Professor Adams conceived and coordinated the extensive ceremonies for Bunker Hill Day on June 17, 1975; he had a major part in helping to save and restore many Revolutionary sites in Greater Boston.

"By personal example and dedication," said Professor Herbert H. Richardson, '53, Chairman of the Department of Mechanical Engineering, "Professor Adams inspired in generations of students and colleagues a spirit of intellectual honesty and precision as well as deep concern for people and their historical heritage." □

Francis W. Sears, 1898–1975

Francis W. Sears, '20, who taught physics at M.I.T. for 38 years before becoming Chairman of the Department of Physics at Dartmouth, died in Hanover, N.H., on November 12. He was 77.

With Peter Debeye, Professor Sears discovered the interaction of light and sound waves (the "Debeye-Sears effect") in transparent material. He was widely admired as a teacher, and Professor Sears' text on *Principles of Physics* sold millions of copies.

Professor Sears retired as Chairman of the Department at Dartmouth in 1964, and he was Appleton Professor Emeritus at the time of his death. He held both undergraduate and Master's (1924) degrees in physics from M.I.T. □

Deceased

Charles E. Smith, '00; September 21, 1975; 48 Beechwood Ln., New Haven, Conn.*

Henry R. Sewell, '08; October 12, 1975; c/o Stetson Manor, Barstow St., Norwell, Mass.*

John E. Barnard, '10; November 13, 1974; 60 Main St., Osterville, Mass.

Alfred Hague, '10; October 19, 1975; 631 S.W. 6th St. 804, Pompano Beach, Fla.*

Robert P. Waller, '10; October 17, 1975; Meadow Lakes, Apt. 1307 U, Hightstown, N.J.

Ove Collett, '11; June, 1970; Cort Adelers Qt. 16, P.O. Box 2428 Solli, Oslo 2, Norway

Roy D. Van Alstine, '11; July, 1974; 3737 Atlantic Ave, Apt. 1001, Long Beach, Calif.

Raymond E. Wilson, '12; August 19, 1975; 304 Park Ave., Swarthmore, Penn.

Robert V. Townend, '14; August 22, 1975; Morristown, N.J.

David M. Shohet, '16; June 24, 1975; P.O. Box 62, West Medford, Mass.

Richard H. Catlett, '17; June 17, 1975; 410 Somerset Ave., Richmond, Va.

Vincente F. Checa, '17; June 29, 1975; Ave. Salaverrez 3580, San Isidro, Lima, Peru

Vallette S. Church, '17; August 30, 1975; P.O. Box 341, 1715 Main St., Cotuit, Mass.

Charles L. Coburn, '17; May 24, 1975; 158 Coronado Ave., Los Altos, Calif.

Frank S. Krug, Jr., '17; October 12, 1972; 2552 Madison Rd., Cincinnati, Ohio

William H. Banks, '19; September 28, 1975; 170 South Rd., Rye Beach, N.H.*

Arthur W. Morse, '21; March 7, 1975; 1055 Washington Blvd., Stamford, Conn.*

Philip A. Nelles, '21; July 13, 1975; 21 Sunset Rd., Stoneham, Mass.

Charles H. Whittum, '22; August 7, 1975; Rt. 2 Box 203, Rock Hall, Md.

Frederick E. Bastion, '23; June 17, 1975; 1019 85th St., Niagara Falls, N.Y.

Samuel T. Dubitsky, '23; August, 1975; 362 Nayott Rd., Barrington, R.I.*

Uncas A. Whitaker, '23; September 16, 1975; Harrisburg, Penn.

Eugene E. Cronin, '24; August 4, 1975; c/o Rex, 105 Grover Ave., Winthrop, Mass.

Samuel J. Hatfield, '24; June, 1975; 124 Charlotte St., Burlington, Vt.

Simon Kirshen, '24; October 24, 1975; 135

Waban Hill Rd., Chestnut Hill, Mass.*

George Riegl, '24; June 24, 1975; Carmel Valley Manor, P.O. Box 6087, Carmel, Calif.*

Gordon Wheeler, '24; March 18, 1975; 333 W. Market St., Troy, Ohio*

John Albert Carnagey, '25; September 20, 1975; P.O. Box 741, Badin, N.C.*

Willard E. Edwards, '26; August, 1975; Apt. 622, 1434 Punahou, Honolulu, Hawaii

Paul C. Eaton, '27; September 18, 1975; Box 753, Kennebunkport, Maine

Richard T. Davidson, '28; October 3, 1975; 962 Tropic Blvd., Delray Beach, Fla.

Ralph B. Atkinson, '29; June 11, 1975; Casa De Castro, 1224 Castro Rd., Monterey, Calif.*

Bernard B. Brockelman, '29; August 26, 1975; 10 Fearing Dr., Westwood, Mass.

Thomas V. Moore, '29; August 19, 1975; 18507 Prince William Ln., Houston, Tex.

William S. Tyler III, '29; September 16, 1975; P.O. Box 291, San Marcos, Calif.*

Arthur R. Partington, '31; March 18, 1975; 365 Manchester Rd., Ridgewood, N.J.

Erwin O. Kruegel, '32; August 12, 1975; 4501 Connecticut Ave. N.W., Washington, D.C.*

Oliver H. Scharnberg, '32; October 20, 1975; 217 Grove St., Westwood, Mass.*

Norman Levinson, '33; October 10, 1975; 131 Sewall Ave., Brookline, Mass.*

Charles E. Miller, '33; April 3, 1975; c/o O. G. Daniels., 8105 Flourtown Ave., Philadelphia, Penn.

H. Page Cross, '36; August 28, 1975; 157 E. 75th St., New York, N.Y.*

Clifton L. Norton, '43; May 25, 1975; 2013 Commonwealth Ave., Brighton, Mass.

Thomas F. Dolan, '44; October 26, 1975; Essex St., Middleton, Mass.

Joseph J. Schaefer, '44; October, 1975; 66 Hubbard Rd., Weston, Mass.

Martin M. Phillips, '47; October 4, 1975; 41 Avalon Rd., Waban, Mass.*

Stewart W. Sennett, Sr., '49; September 14, 1975; R.F.D. #3, Box 250, Coffee Run Dr., Hockessin, Del.

Frank B. Connelly, '50; September 9, 1975; 719 W. Highland Ave. Elgin, Ill.

Robert E. Nahm, '50; July 4, 1975; 49 Mile Rd., Suffern, N.Y.

Richard D. Goss, '51; August 1, 1975; 24 Rockland St., Swampscott, Mass.*

John R. McMaster, '55; September 23, 1975; 9403 McLennan, Sepulveda, Calif.

Joseph B. Norvell, '57; July 27, 1975; 9804 Hedin Dr., Silver Spring, Md.

William L. Sacks, '61; October 15, 1975; 546 Twitchell Rd., Mansfield, Ohio

Clarence O. Thornburg, Jr., '66; August 1, 1975; Rte. 1–Box 282, Dallas, N.C.

Timothy W. Holm, '75; June 20, 1975; 2738 Pleasant Hill Rd., Pleasant Hill, Calif.

* Further information in *Class Review*

70 New Young Faculty; Future Leaders of M.I.T.

Seventy new members of the M.I.T. faculty with the rank of Assistant Professor are completing their first months of teaching on the faculty. Their appointments, announced during the spring and fall, are evidence that despite budget stringencies "new blood" is joining the M.I.T. faculty regularly to assume leadership roles in coming decades. The new appointees:

— **Donald B. Anthony,** Sc.D. '74, is Assistant Profesor of Chemical Engineering in charge of the Bound Brook (N.J.) Station of the School of Chemical Engineering Practice, where he supervises some 12 M.I.T. graduate students working at American Cyanamid Co.

— **Raymond M. Baker,** Department of Biology. A graduate in biophysics from Yale and the University of California (Berkeley), Dr. Baker has worked on cancer research and medical biophysics at the University of Toronto; he will be associated with the M.I.T. Center for Cancer Research.

— **Arnold I. Barnett,** Ph.D. '74, has taught mathematics at M.I.T. and is now Assistant Professor in the Sloan School of Management; a specialist in applied mathematics, he is the author of a widely reported study of homicide rates in American cities.

— **Klaus J. Bathe,** Department of Mechanical Engineering, came to the U.S. after completing civil engineering training at the University of Cape Town, South Africa; he has since been at the Universities of Calgary (Canada) and California (Berkeley) where, before January 15, he was developing computer programs for structural analysis.

— **James M. Becker,** Department of Civil Engineering, has held consulting and management assignments for the Center for Environmental Structure (Berkeley), Inland Steel (Chicago), and Shell Oil Co. (New Orleans). His degrees in structural design are from Cornell and the University of California.

— **John R. Bennett,** Department of Earth and Planetary Sciences. After study at the University of Wisconsin, Dr. Becker has been General Physical Scientist for Project Lake Ontario, a N.O.A.A.-sponsored program under the International Field Year for the Great Lakes.

— **Zvi Body,** Ph.D. '75, Sloan School of Management. Formerly an instructor in economics and finance in the Boston University School of Management, Dr. Body studied philosophy at Brooklyn College and economics at Hebrew University, Jerusalem, before enrolling at M.I.T. for his doctorate in economics.

— **George W. Brandenburg,** Department of Physics, has spent his first term on the M.I.T. faculty working in an experimental group at the Fermi National Accelerator Laboratory, Chicago. His degrees are from Harvard, and he has studied and worked at the Max Planck Institut für Physik in Munich and the Stanford Linear Accelerator Center.

— **Leonard G. Buckle,** '64, is co-reporter with his wife, Suzann (*see below*), to the American Bar Association on a juvenile justice standards project at M.I.T. He holds degrees from the Institute in electrical engineering, management, and urban studies and planning, the department whose faculty he has joined.

— **Suzann T. Buckle,** Ph.D. '74, is coordinator with her husband (*see above*) of law-related studies in the Department of Urban Studies and Planning, where she is also Associate Director of the undergraduate program. Her earlier degrees are in English and Biblical studies from Wellesley.

— **Claude R. Canizares,** Department of Physics. While studying at Harvard, Dr. Canizares was associated with the Cambridge Electron Accelerator; since 1971 he has been working on data acquisition from X-ray astronomy experiments in the M.I.T. Center for Space Research.

— **Rowland M. Cannon, Jr.,** '66, Department of Materials Science and Engineering. Dr. Cannon's undergraduate and graduate degrees (Ph.D., M.I.T., 1975) have been in the field of ceramics, and his research in that field at M.I.T. has resulted in a patented ceramic-to-metal seal system.

— **Flora Y. F. Chu,** Department of Electrical Engineering. Dr. Chu's degrees are from the University of Wisconsin, where she has been a lecturer in electrical engineering.

— **Joel P. Clark,** Sc.D. '72, Department of Materials Science and Engineering. Dr. Clark's appointment is in the field of materials systems; he comes to the Institute from a post as Project Manager at Texas Instruments, Inc., Attleboro, Mass.

— **Phillip L. Clay,** Ph.D. '75, Department of Urban Studies and Planning. Dr. Clay has taught in the Department while working on his Ph.D. degree, and he has also been a fellow of the Joint Center for Urban Studies of Harvard and M.I.T.

— **Carlos F. Daganzo,** Department of Civil Engineering. As a graduate student at the University of Michigan, Dr. Daganzo worked on dial-a-bus systems and traffic routing models; his undergraduate degree is from the University of Madrid.

— **Owen L. Deutsch,** Ph.D. '75, Department of Nuclear Engineering. Dr. Deutsch came to M.I.T. for graduate work after research assignments at Los Alamos Scientific Laboratory; he is now helping several Boston-area hospitals with radiation shielding studies for diagnostic and therapeutic radiology.

— **James W. Driscoll,** Sloan School of Management. Dr. Driscoll is a specialist in organizational behavior, and he taught at the New York State School of Industrial and Labor Relations while studying for his Ph.D. at Cornell; his earlier degrees are from Harvard College and the Harvard Business School.

— **Clarence A. Ellis,** Department of Electrical Engineering and Computer Science. Formerly Assistant Professor at the University of Colorado, Dr. Ellis comes to M.I.T. from the I.B.M. Watson Research Center. His degrees, from Beloit College and the University of Illinois, are in physics, mathematics, and computer science.

— **Lloyd S. Etheredge,** Department of Political Science. Following studies at Oberlin and Yale, Dr. Etheredge taught at the University of Manitoba before coming to the Institute. His research is in political behavior, psychology, and policy formation.

— **Christos Georgakis,** du Pont Assistant Professor in Chemical Engineering. Dr. Georgakis is teaching chemical kinetics and reactor design. His degrees are from the Universities of Athens, Illinois, and Minnesota, and he has taught at the University of Minnesota.

— **David C. Gossard,** Ph.D. '75, Department of Mechanical Engineering. As an M.I.T. graduate student, Dr. Gossard was coordinator of the Engineering Project Laboratory and worked with the joint civil engineering-mechanical engineering computer facility; his earlier degrees are from Purdue.

— **Edward M. Graham,** Sloan School of Management. A graduate of the Harvard Business School, Dr. Graham's current research is on multinational enterprise; he has been on the teaching staff of the Central American Institute of Business Administration in Managua, Nicaragua, and more recently has taught at Northeastern and Babson College.

— **Frederick L. A. Grauer,** Sloan School of Management. A consultant to the Institute for the Future, Dr. Grauer studied economics and finance at British Columbia, Chicago, and Stanford.

— **Ted R. I. Greenwood,** Ph.D. '73, attended the tenth Pugwash Conference as rapporteur (1970) and has since held research appointments in international affairs at Harvard and M.I.T. His degrees are in mathematics, physics, and political science.

— **Alan J. Grodzinsky,** '69, won the Goodwin Medal "for conspicuously effective teaching" as a graduate student in electrical engineering — the Department to whose faculty he has now been appointed. He is principal viola in the M.I.T. Symphony Orchestra.

— **Robert L. Jaffe,** Department of Physics. While completing his doctorate at Stanford Dr. Jaffe was associated with the Stanford Linear Accelerator Center; since 1972 he has been a post-doctoral research fellow at M.I.T.

— **David J. Jansson,** '68, Department of Aeronautics and Astronautics. Dr. Jansson has worked in the Charles S. Draper Laboratory and as Program Director for Information Systems Devices at the U.S. Office of Naval Research, where he designed a new respiratory protective device for firefighters. His three degrees are from M.I.T.

— **John D. Joannopoulos,** whose research is on the theory of disordered systems and the properties of surfaces, comes to the Department of Physics from the Uni-

versity of California.

— **Charles L. Jones,** Department of Political Science. A specialist in social mobility, survey analysis, and modeling social processes, Dr. Jones is a permanent lecturer at the University of Edinburgh, where he received his Ph.D.; his earlier training was at Cambridge University and the London School of Economics.

— **Manohar U. Kalwani,** Sloan School of Management. While completing his Ph.D. at the Columbia Graduate School of Business, Dr. Kalwani taught business mathematics and computer programming. He came to Purdue for his master's degree after studies at the Indian Institute of Technology, Bombay.

—**Edward C. Kern, Jr.,** Ph.D. '73, has been teaching marine hydrodynamics in the Department of Ocean Engineering while studying oil pollution control barriers and consulting on hydrodynamics at Lincoln Laboratory. He holds undergraduate degrees from Dartmouth.

— **Alcira G. Kreimer,** Departments of Urban Studies and Architecture. As a practicing architect in Buenos Aires from 1968 to 1970, Dr. Kreimer specialized in communication environments and multi-media events. She will teach environmental design, the field of her graduate study at the University of California (Berkeley).

— **Yue-Ying Lau,** '68, Department of Mathematics. As an undergraduate and graduate student at M.I.T., Dr. Lau specialized in astrophysics while earning degrees in electrical engineering. His teaching will be in applied mathematics.

— **David Lee,** Department of Architecture. Currently with Stull Associates, Professor Lee has consulting assignments in New Orleans and Houston and with the Roxbury Action Program, Boston; his architectural degrees are from the University of Illinois and Harvard, and he has taught at M.I.T. since 1973.

— **Roberto L. Lenton,** Ph.D. '74, is a native of Buenos Aires with professional interests in water resources and river hydrology; he has been in the Department of Civil Engineering at M.I.T. since completing undergraduate work in Argentina.

— **Steven R. Lerman,** '72, Department of Civil Engineering. Dr. Lerman's special field is the relationship between urban transport, land use, and household relocation, and he has worked in this area as an undergraduate and graduate student at the Institute.

— **James H. McClellan,** Department of Electrical Engineering and Computer Science. Dr. McClellan came to Lincoln Laboratory in 1973 to work on digital signal processing for high-performance radar; his degrees are from Louisiana State and Rice Universities.

— **Sitikantha Mahapatra,** Sloan School of Management. Formerly at the Indian Institute of Management, Dr. Mahapatra came to the U.S. for his doctorate (Case Western Reserve University) in 1974 and since then has taught quantitative analysis and control at Bowling Green State University.

— **Manuel Martinez-Sanchez,** Ph.D. '72, Department of Aeronautics and Astronautics. A specialist in magnetohydrodynamic laser and coal combustion, Dr. Martinez-Sanchez studied at the University of Madrid before coming to M.I.T. in 1967.

— **Nathaniel J. Mass,** '72, Sloan School of Management. Dr. Mass, whose Ph.D. is also from M.I.T. (1974), has taught workshops in economic theory and industrial dynamics, and he is currently Director of the Systems Dynamics National Modeling Laboratory in the Sloan School.

— **Carol D. Meyer,** Department of Chemistry. As a postdoctoral fellow at the University of Rochester, Dr. Meyer worked in the field of organometallic chemistry; her graduate research at Brown was in carbonium ion chemistry.

— **Philip C. Myers,** Ph.D. '72, Department of Physics. Mr. Myers will continue work on the design, construction, and testing of radiometers which he began as staff physicist in the Research Laboratory of Electronics; he came to M.I.T. from Columbia in 1966.

— **Owen H. Oakley, Jr.,** Ph.D. '72, Department of Ocean Engineering. Professor Oakley's appointment is in the field of naval architecture; he has studied at the University of Michigan and has done research in ship design at the University of California and the Technical University at Delft, the Netherlands.

— **William H. Rastetter,** '71, Department of Chemistry. As a graduate student at Harvard working on natural product synthesis and biogenesis, Dr. Rastetter won Harvard's award for excellence in teaching chemistry (1973); his Harvard Ph.D. was awarded last June.

— **David D. Redell,** Department of Electrical Engineering. Until this year at the University of California, Dr. Redell participated in the design and construction of a medium-sized computer system for a single laboratory and later of a large-scale general-purpose system for the campus computer center.

— **Eugenia Rivas,** Ph.D. '71, Department of Meteorology. A native of Buenos Aires, Dr. Rivas spent two years at the University of Montevideo, Uruguay, from 1971 to 1973 before returning to the Institute as Research Assistant.

— **Ronald L. Rivest,** Department of Electrical Engineering. Dr. Rivest has been at Yale and Stanford Universities and since 1973 has been Scientific Director of the French Institute de Recherche d'Informatique et d'Automatique.

— **Nils R. Sandell, Jr.,** Ph.D. '74, worked last year with the M.I.T. Center for Advanced Engineering Study preparing computer programs for linear systems and accompanying video-taped lectures; his appointment is Assistant Professor of Systems Science and Engineering in the Department of Electrical Engineering.

— **Richard R. Schrock,** Department of Chemistry. After completing his doctorate at Harvard in 1971, Dr. Schrock held a postdoctoral fellowship at Cambridge University and served as research chemist in the du Pont company's Central Research and Development Laboratory.

— **Adrian Segall,** Department of Electrical Engineering. Dr. Segall studies at The Technion and from 1968 to 1971 served as research engineer in the Scientific Department of the Israel Ministry of Defense; more recently he has been with Systems Control, Inc., Palo Alto, Calif.

— **Barbara Sirota,** Department of Humanities. Dr. Sirota is completing her doctorate at Brown University, where she was one of the first persons in the U.S. to offer a course in women's studies. Her teaching at M.I.T. is in 17th- and 20th-century literature.

— **Robert J. Slattery,** B. Arch. '70, is codirector of a project to renovate and modernize the M.B.T.A. Park Street subway station and has designed major buildings for Hampshire College, Amherst, Mass., as Principal and Director of Arrowstreet, Inc., architects, planners, and environmental designers of Cambridge. His appointment is in the Department of Architecture.

— **Edward I. Solomon,** Department of Chemistry. Dr. Solomon came to M.I.T. last fall from the Noyes Laboratory of the California Institute of Technology, where he was research fellow. His degrees are from Rensselaer and Princeton, and he has had a postdoctoral year at the University of Copenhagen.

—**Ralph H. Staley,** Department of Chemistry. Prior to his graduate work at California Institute of Technology in ion-molecule reactions and thermochemistry, Dr. Staley was research physicist at Feltman Research Laboratories, Dover, N.J.

—**Liba Svobodova,** Department of Electrical Engineering and Computer Science. Dr. Svobodova, whose degrees are from the University of Prague and Stanford University, came to the Institute from a junior faculty post at Columbia University.

— **Peter Szolovitz,** Department of Electrical Engineering, comes to M.I.T. from graduate study at the California Institute of Technology. His research is in the field of automatic programming.

— **Hoo-min D. Toong,** '67, is responsible for maintaining the Digital Systems Laboratory, the undergraduate digital logic teaching facility in the Department of Electrical Engineering. He has earlier been associated with the Research Laboratory of Electronics and Project MAC while earning graduate degrees at M.I.T., and he has had professional experience with several industries.

— **Harry L. Tuller,** Department of Materials Science and Engineering. Dr. Tuller comes to M.I.T. from the Technion, Haifa, Israel, where he supervised research in metal oxide properties. His academic work was at Columbia University.

— **Daniele Veneziano,** Ph.D. '74, came to M.I.T. from Italy in 1971. He has taught at the Institute of Minerals and Structures in L'Aquila, Italy, and his current research in soil properties is in cooperation with a UNESCO project at the National University of

Mexico.

— **Anne Vernez-Moudon,** Department of Architecture. A teacher in the College of Environmental Design at the University of California (Berkeley) since 1973, Ms. Vernez-Moudon was previously associated with architectural firms in San Francisco and New York.

— **J. Kim Wandiver,** Ph.D. '75, Department of Ocean Engineering. Dr. Wandiver returned to M.I.T. to complete graduate studies in 1971 after serving with the Army Corps of Engineers in Vietnam.

—**Stephen A. Ward,** '66, has worked in the field of computer graphics in M.I.T.'s Education Research Center and Department of Biology; now he has completed his Ph.D. and joined the faculty in the Department of Electrical Engineering.

— **Cardinal Warde,** Department of Electrical Engineering. Professor Warde is a native of Barbados who studied at Stevens Institute of Technology and Yale, where he has been on the teaching staff since 1971.

— **Martha W. Weinberg,** Department of Political Science. A specialist in educational services, Dr. Weinberg was for two years an analyst for the Illinois Bureau of the Budget and has more recently been Assistant to the Massachusetts Secretary for Human Services. Her degrees are from Smith, Wisconsin, and Harvard.

— **Stanley A. West** comes to the Department of Civil Engineering from the Anthropology Department at Western Michigan University. A specialist in computer applications in anthropology, he has worked among Mexican Americans and Puerto Ricans completing a doctoral thesis on the Mexican Aztec society.

— **John L. Wilson, III,** Ph.D. '74, is in the Department of Civil Engineering to supervise a program for training four Spanish engineers and one economist in groundwater management and policy.

— **Andrew C.-C. Yao,** Department of Mathematics. Dr. Yao's specialty is mathematical problems related to computer science; he holds degrees in physics from National Taiwan University and Harvard and in computer science from the University of California (Santa Barbara).

— **Ronald W.-C. Yeung,** Department of Ocean Engineering. Dr. Yeung has worked as a naval architect in engineering and shipbuilding firms in San Francisco, and at M.I.T. he is developing numerical methods for computing hydrodynamic forces.

— **George J. Yurek,** Department of Materials Science and Engineering. Dr. Yurek's research at Oak Ridge National Laboratories and Bethlehem Steel Corp. has been in metallurgical failure analysis; he studied at Penn State and Ohio State Universities. □

There's a bit of a child in every visitor to The Exploratorium, San Francisco's science museum devoted to exhibits through which viewers can explore the mechanisms of their own perception," in the words of Frank Oppenheimer, its Director. The pictures were made during a three-hour private opening of the museum late last fall for the M.I.T. Club of Northern California. A feature of the afternoon was a brief description by Louis Alvarez (right), Nobel laureate physicist at the Lawrence Radiation Laboratory, of cosmic ray research represented in museum exhibits. (Photos: Philip Molten, '55)

Class Review

96

Chief news for this month is the birthday of our member, **Richard O. Elliot.** On February 6 he will celebrate the 103rd anniversary of his arrival in the state of Maine. Happy Birthday! — **Clare Driscoll,** Acting Secretary, Cliff St., Plymouth, Mass. 02360

00

Charles E. Smith of New Haven, Conn., died on September 21, 1975 at the age of 98. "A railroad man to the end," said the *Boston Globe* about the retired vice president of the New York, New Haven and Hartford Railroad.

"Mr. Smith, a native of Somerville, worked his way through school as a special delivery messenger for the Somerville Post Office. After graduation from the Massachusetts Institute of Technology in 1900 he joined the N.Y.N.H. and H. Railroad as a bridge designer.

"In 1907 he was appointed bridge engineer of the Missouri Pacific Railroad and was in charge of the design, construction and maintenance of all bridges on 7,200 miles of track in ten states. After several years with the Missouri Pacific he became consulting engineer to the city of St. Louis and remained there for 12 years.

"He returned to the New Haven Railroad in 1928 and for the next 21 years he was simultaneously vice president to assist the president, and vice president of the following subsidiaries: New England Transportation Co., County Transportation Co., and the New England Steamship Co.

"He retired from the New Haven in 1949 and was later named railroad consultant to the government of Spain and was retained by the World Bank as a consultant for the improvement of rail service in Brazil.

"Mr. Smith served in World War I. During World War II he was petroleum procurement specialist for the War Production Board. He was president of the All Technology Alumni, a term member of the Corporation at M.I.T. and class agent of the alumni fund.

"He was awarded a gold medal by the American Society of Civil Engineers for deep foundation work." — S.F.

03

Well, happy classmates, our year is near a close, and a welcome word from you of personal activity during the year is urgently needed.

I still keep active and recently gave a talk to a crowded audience at the Somerville Historical Building on the enlightening subject of "Somerville 80 Years Ago." I enjoy the reports in our *Review* on various ways to conserve energy.

Our Happy Birthday celebration for **Adolph E. Place,** December 21, 1876, Boulder City, Nevada; and **Stanley A. Foster,** December 29, 1876, 254 Foster St., Lowell, Mass. — **John J. A. Nolan,** Secretary-Treasurer, 13 Linden Ave., Somerville, Mass. 02143

08

We regret to report the passing of another classmate, **Henry R. Sewell,** of Lincoln St., Norwell, Mass., who died at the Stetson Manor Nursing Home on October 12, 1975. His wife was the late Clair (Welch) Sewell, a 1910 graduate of Smith College whom he survived by about two months. They have one daughter, Mrs. Lucie Marshall, of Sea Ranch, Calif. A very complete report of Henry's work may be found in the May, 1973 *Technology Review.* A class get-together was held in 1951 at their home in Norwell. I took a picture of this event, and left a copy with the M.I.T. Historical Collection.

The Sewells were regular attendants at our '08 reunions at the Melrose Inn and probably, next to the last of our class to return to the old Inn at Harwich Port. My wife and I were fortunate to be there when Henry and Claire were there two years ago.

Henry was a noted mechanical engineer and vice president of the Sturtevent Co. of Hyde Park, now a division of Westinghouse.

A private graveside service was held at the Forestvale Cemetery of Hudson, Mass. We sent an appropriate gift in memory of Claire and Henry Sewell, to the First Parish of Norwell.

Just something of concern. We have two kinds of time, standard and fast time. Fast time is one hour ahead of standard time and starts on the last Sunday of April, and gives an extra hour of daylight during the summer. Most every home has several electric clocks. It is generally simple to push the hands of the electric clocks ahead one hour for fast time, but often it is difficult to get them back to standard time, on the last Sunday of October. Here is what I do, for this change: when everyone is asleep on Saturday night of the change, pull the main electric switch that supplies the house. for *just one hour*. When the switch is closed again every electric clock will start on standard time. — **Joseph W. Wattles III,** Secretary, 26 Bullard Rd., Weston, Mass. 02193

10

We regret to report the death of **Alfred Hague** on October 19 at his home in Pompano Beach, Fla. Our deep sympathy is extended to his widow, Janet. Al was a very loyal member of our class and he and Janet attended our five-year reunions regularly until our 65th at which time his illness prevented their being with us. He was born in New York City and attended Choate School at Wallingford, Conn., before entering M.I.T., where he majored in mechanical engineering. In 1910 he became one of the early coast-to-coast automobile travelers in his Oldsmobile, driving with a friend from Boston to Portland, Ore. Al became interested in radio in its early years and went to Japan to interest engineers there. While in Japan, he climbed the celebrated Mt. Fuji. During World War I, he served in England from 1917 to 1919. He had a Naval Aviation appointment to the Isle of Man, where he received his commission. In later years he formed his own company in New York State, where he developed a widely used "coating" for manufacturing and industry. In 1913 he had been an early visitor to Florida, fishing for tarpon off the coast of a small community called Miami. In 1958, upon his retirement, he took his motor boat along the intracoastal waterway from New York State to Florida and settled at Pompano Beach. There, he became very active in civic and community affairs, which continued until his final illness. Besides his widow, Janet, he leaves several nieces and nephews.

On the trip back to their home at Boynton Beach, Fla., after our 65th Reunion, **Carl Lovejoy** and his wife Glenna detoured to Black Mountain, N.C., near Asheville. They stayed for the rest of the summer at an Inn which they visit almost every year. The scenery and the climate are excellent in that part of the state, and Carl says they find a very congenial group for bridge.

The following "1910" men attended the fall dinner meeting of the M.I.T. Club of Western Maine: **Jack Babcock** (Secretary of the Club), **Fred Lufkin** and **Chet Wilson** (of Barrington, N.H.). Although we were

members of the earliest class in attendance, there was one each from the Classes of '11, '12, and '13, as well. Apparently, not all M.I.T. retirees have left Maine for southern climes! — **John B. Babcock,** Secretary, 33 Richardson St., Portland, Me. 04103

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We hope you are beginning 1976 with high hopes in your retirement. **Fred Lane** advised us of **Marion Rice Hart**'s solo flight to the MidEast:

"If you take the federal employees' *Retirement Life,* the October issue cover is a picture of Marion Rice Hart, the oldest woman to fly solo across the Atlantic. Quite a few of us will recall her working in the electrical lab with us and as being expert in blowing the fuses! Besides this news I have little else to say. I guess we have come to the point in age where we must give up long cross-country drives. So here we stay, at home, but still well." Fred and his wife expect to be with us at our 65th Reunion for two days.

Edward Jewett reports: "Regarding the reunion, I will be unable to attend. I have not been in Boston for at least ten years. I am still able to keep active locally." . . . **Joseph Isenberg** sends greetings and "kindest regards." . . . **George Wallace** reports: "Unfortunately for me I am pretty well tied up with arthritis so even if you do have a class reunion meeting I won't be able to attend. With my kindest regards and best wishes." . . . **E. M. Bridge** states: "I dislike being far from Wakefield and sorry I'll not go to Boston. Best wishes." . . . **David Stern** writes: "Maintaining same activity with Rotary, hospital, and consulting on a leisurely basis."

Allen Brewer as usual writes an interesting letter and we quote: "Today we are quite free from weather tribulations for a change. No bad blows, and too little rain, until recently. Now with the chill of autumn in the air — 68° this morning — we can rest easy and plan on our garden. To fill in my spare time aside from collating our West Indies stamps, I have written a bit just to keep my hand in. My most recent piece appeared in the Texaco Stamp Club 'Philatelic Footnotes.' Here is a copy which you, Roz, may particularly enjoy. It's my tribute to 'Mothers of America' as portrayed by U.S. stamps. It seems to fit in nicely with our present Women's Year. There is not much other news for you folks. We are both 'in the pink' as the saying goes. Had an eye check-up the other day. All O.K. with both eyes and the contact lens is second nature to me now. Maurine is presently in Westchester County, N.Y., helping her sister and brother-in-law prepare for their permanent move down here. They have bought a piece of land very close to us and hope to start building very soon."

Vernon Kay writes: "For those who wish it. I do not." . . . **Charlotte Sage** writes: "Back in town — more crowded and dirtier than ever — but good to be back in harness. For the reunion — I can't imagine old crocks like us spending four days — but I do think two would be good. Those from far away could at least spend a night. I live so near that it is O.K. with me whatever you decide." . . . **Emerson L. Bray** is one of our hopeful classmates and he replies as follows: "Thanks, George, for your wonderful service to our class. Everything is O.K. at Upper Darby, Penn. I don't know how you do it on such low class dues." . . . **George Bakeman,** always an enjoyable correspondent writes: "Nothing exciting here to report. Some asthma and arthritis, but otherwise both Mollie and I are in excellent health. Some gardening and grass cutting plus usual household chores; local driving only."

We received a note from **Bill Brewster**'s wife, Ellen, advising us that Bill is now in a nursing home in Plymouth. However, physically he is doing fairly well.

So long for now. We shall give you more of the results of the vote for our 65th Reunion next issue. — **George Philip Capen,** Secretary-Treasurer, **Rosalind R. Capen,** Asst. Secretary, Granite Point Rd., Biddeford, Maine 04005

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As nothing for this issue has come from anybody, I trust that no news is good news, and wish everybody a Happy New Year. — **Charles H. Chatfield,** Secretary, 177 Steele Rd., West Hartford, Conn. 06119

15

Happy New Year! With the hope that you and your families have all enjoyed a pleasant holiday season.

With the frightful and tragic conditions in Lebanon, I wonder what has become of our classmate, **Bahjat Abdulnour**. After graduating in Course IV, he returned to his native Beirut and developed a successful business in architecture and building and road construction. In the spring of 1971 he sent me an interesting booklet with pictures and descriptions of many of the jobs he had done, several for American firms. Some of his old Course IV friends wrote him and I sent folders, pictures and catalogues of the new M.I.T. for him to see the changes. But, it all stopped suddenly — a pity! . . . **Frank Boynton** is living comfortably at a nursing home in Alhambra, Calif. . . . **Henry Daley** says he is sorry that old age has prevented his attending the last few class parties. All the best to you, Henry, for comfort and good health — we're all simply getting older! . . . I've seen **Wayne Bradley** often lately, and he continues, remarkably, a "ball of fire." I hope he can keep it up. — **Azel W. Mack,** Secretary, 100 Memorial Dr., 2-6A, Cambridge, Mass. 02142

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Our best wishes to all of our classmates for a very happy and healthy new year.

This is the year of our 60th Reunion, and reservations have been made at the Chatham Bars Inn for June 1 to 3. This again is on Tuesday through Thursday so that we can avoid the weekend travel crush. Alumni Days in Cambridge begin Thursday night with Tech Night at the Pops; and the all-day program is Friday, June 4. We anticipate an excellent attendance at both; and if there is anything we can do to help in plans to attend, let us know.

Hank Smith writes his thanks for the picture of the '16ers who attended the 1975 reunion. "I wish I could have been there," he writes, "but it is a very difficult trip to Chatham, Mass., from Lakewood, N.J. However, I hope — and really expect — to be able to make it for the big 60th next year. My wife, Dorothy, passed on in January, 1972, and since then I have been living alone (not much fun) in the house we bought here in Leisure Village, Lakewood, N.J. I guess I'll wind up my career right here, for a move is not in the cards." . . . **Maury Holland** recently wrote that he was to attend a three-day meeting of the Policy and Planning Committee of the Industrial Research Institute of which he is a founder, in Cincinnati. One of the matters under discussion was a visit next spring of 40 to 50 I.R.I. representatives to Japan. Ten members of Japan's I.R.I. group attended the meeting in Cincinnati to study small technologically-based venture capital companies, mostly I.R.I. companies. An interesting sidelight to Maury's trip was an opportunity to visit with his son, who evidently takes after his father. "Sonny flies down from Bloomington — his second year training on cross-country — and flies me back to Bloomington after the weekend with him." You may recall that Maury was one of the pioneer pilots in World War I.

We were happy to hear from **Jap Carr,** but concerned by his note that "I got mixed up and find I made a reservation on the Auto-Train coming north on June 8, and am afraid this will conflict with the Reunion dates. But Hildegarde and I are looking forward to the Reunion, and possibly we can fly to Boston for the Reunion and back to Florida for the Auto-Train trip north for the summer." . . . **Joe Barker** recently resigned as our Class Agent and Class Estate Secretary, and fortunately for us Jap has graciously agreed to accept this responsibility. Let's give Jap the same wonderful response that we gave to Joe's leadership during his many successful years.

We are pleased to know that **Ruth Kemp** is well and again living in Wellfleet. You will recall that she and **Emory** retired to Florida, and shortly before Emory's death last June they made the decision to return to Wellfleet. . . . We've had a couple of contacts with **Harold Dodge** and we're pleased to report that he and Grace are well. He sent us the notice on **Merrick Monroe,** who died on April 3, 1975; he was associated with the Duval Separator Co. and the Ohio Pattern Works and was retired as an industrial specialist with the Small Business Administration in New York City. Harold also notified us that **Earl Mellen** passed away on November 3, 1975. We send our sincere sympathy to their loved ones.

Please keep writing; your classmates look forward to reading about you. — **Ralph A. Fletcher,** Secretary, P.O. Box 71, West Chelmsford, Mass. 01963

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Our 58th Reunion at Northfield, Conn., in October was declared a happy one. The attendance was a record 30 men and 23 ladies. This total of 53 was significant compared with our past averages of 33. Also remarkable was that 91 men out of 159 on our active mailing list returned the post cards.

The weather was good, the foliage superb, the boat trip on the Connecticut River fun, though chilly. **Stan Lane** brought lovely dahlias from his garden to decorate

Class of 1917, 58th Reunion at Northfield, Conn.

the tables, and showed his 1961 movies of the Canadian Rockies, as well as some slides of '17ers taken from the 1918 *Technique*. He also gave the treasurer's report, which indicated the need for some "dues" payments in view of current expenses and anticipated ones for our 60th Reunion. Of course as class photographer he showed pictures of past reunions and took new ones.

We were particularly happy to have Honorary Members Jay and Kay Stratton and Don and Phyl Severance with us again. Don gave an interesting talk on the Tech of the past and present. His slides of our "olden days" provoked happy recollections. His emphasis was that Tech then and now is people.

The distance record for attendance went to Helen and **Jack Wood** from San Diego, followed by **Dutch Neumann** from Des Moines, with **Frank Peacock** from Chicago as third. Edna and **Brick Dunham** prepared the name tags once again. Helen and **Frank Butterworth** duetted at the piano again and there were a few dancers. Our Banquet social hour was interrupted by the entrance of four individuals in Arab dress. They were finally identified as Christine and **Walt Beadle** and Pat and **Bob Erb** who had recently returned from an Argonaut cruise.

At our business meeting, **Ray Stevens** as Estates Secretary gave a report related to the current M.I.T. Leadership Campaign. The three 1917 Funds were updated. The Memorial Fund had income of $6,020, which (being undesignated) was applied to the Sailing Pavilion Program. The Aldin Fund had income of $5,285 which will assist three students this year. The 1917 Loan Fund, which originally had $3,038, is now at zero since the sum was loaned to the student Chi Kuan Wu, grandson of **P. Y. Hu** and repayment has not yet begun. This fund is for loans to any descendant of a member of the class.

Those attending the reunion besides those already mentioned were: Rom and **Phil Cristal, John DeBell,** Jeanette and **Stan Dunning,** Laura and **Al Ferretti, George Henderson,** Sally and **John Holton,** Doris and **Bill Hunter,** Betty and **Ken Lane,** Helen and **Stan Lane,** Midge and **Dick Loengard, Al Lunn,** Mona and **Walt Lyon,** Claire and **Tom Meloy,** Alice and **Will Neuberg, Jess Rogers,** Dorothy (Mrs. **Ralph**) **Ross, Clarence Seely,** Rose and **Haig Solakian** and their two daughters, Katherine and **Ray Stevens, Dad Wenzell,** and Elizabeth and **Dusty Wilson. — Stanley C. Dunning,** Secretary, 6 Jason St., Arlington, Mass. 02174; **Richard O. Loengard,** Assistant Secretary, 21 East 87th St., New York, N.Y. 10028

18

Serendipity — that is the name of the game for this batch of 1918 news. About a month ago class agent **Julie Howe** and I were discussing Fred Lehman's report of the Alumni Fund for last year. We noted that 1918 was credited with more than $300,000 for the year ending June 30, 1975 — well over ten times the normal annual gifts from our class. I started an investigation at M.I.T. headquarters — it revealed the fact that **Carl Lindgren, Jr.** had left over $300,000 in his will to our Alma Mater. There was no further information except the official legal transmission of the funds by the attorney for a Philadelphia bank. The Alumni records showed he was a regular contributor to the Alumni Fund and that he had been employed by the Atlantic-Richfield Co. Through contacts at A.R.C. we were able to glean that Carl started as a draftsman for them in the early twenties and retired as a project engineer about ten years later. He never married. I wrote three '18ers in the Philadelphia area to see if we could find out more about Carl — and I am grateful to **Ken Pote, Mal Baber,** and **Dave McFarland** for their efforts as per the letters from them. They found that Carl lived with his sister in Havertown, Penn., and that his work concerned heat transfer problems. I would like any of you who knew Carl — and his life in Philadelphia — to write me any information about his church and social or philanthropic interests.

Dave McFarland writes: "I am somewhat handicapped at the moment with eye problems, so that my driving range is limited. I had a cataract operation last November and will likely have another one before long. Otherwise I am in good shape physically and could almost get down to my old wrestling weight of 129 pounds. I keep in shape by being a one-acre farmer and taking care of a good-sized lawn. I am sorry that Boston is so far away that I cannot get back to any of the Institute functions. I am allergic to city driving and would be lost around Boston. Last time I was there was to see my daughter, who lived off of Joy Street on Beacon Hill. Then I had to have a pilot to get me around that section to deliver some things to her apartment."

Malcolm Baber writes: "I think I wrote you before that **Bill Wyer** was in poor shape. He was unable to attend our class dinner (Yale) last spring. Sorry to miss the Mini-Reunion. My best wishes to all."

Here is another adventure in serendipity. In the October/November 1918 notes we included an item from **Wendell Monroe** as follows: "Is there any scientific evidence that a person has a life after death?" We are indebted to **Sumner Wiley** and Reverend **Fred Philbrick,** President of Florida State Spiritual Ministerial Assoc., for replies to Wendell's question.

Fred writes: "The last time I saw Wendell was in San Francisco. He was at that time a consultant for the San Francisco-Oakland rapid transit system. I am sure that I can give him the answer he desires, if he will approach the subject with an open mind.

"I have been a student of psychic matters for approximately 20 years, and have found it most interesting and satisfying. I tried to talk to **Leonard Levine** about the subject when we were at Chatham during the 50th Reunion. He told me blankly that he did not believe me and indicated that he thought I was 'nuts,' so I did not pursue the matter further. As you may know, some of our greatest scientists were convinced of psychic phenomena and the authenticity of many of the 'mediums.' I have witnessed many psychic demonstrations which cannot be explained by any of our basic laws of physics or chemistry. Some day we will learn the truth about these things, and wonder at our present ignorance."

Sumner writes: "I was distressed about Wendell Monroe's question. I haven't the answer but would like to send him a note.

"You asked about the health of that beautiful begonia that the Wiley's acquired (by chance) at the Endicott House a year ago. It is bigger and more luxurious than ever right now. We have it at a south win-

dow in our living room after a summer in the garden outside. It is covered with blossoms."

Len Levine writes "The Mini-Reunion was the best ever. I was quite surprised and pleased when you flashed my picture on the screen (when I had hair). I also greatly enjoyed a 20 minute chat with the ex-president of the Institute. I never had the opportunity of meeting him but he was delightful. Thank you very much for the picture. I recently read in the obituary column that the wife of **Wingate Rollins** died some time during the week of October 27 to 31. I met the two of them at the Pillar House about a year ago and she looked very sick then."

A brief item from **Charles Dimock**: "Bachelor, eat in my apartment and get the *Globe* for news, comics, crossword puzzles, etc. Find a challenge in the latter and follow baseball, football and hockey on radio and TV, Boston teams of course."

We are happy to report that **Sax Fletcher** is making steady improvement in his health after a heart set-back in July. He will be happy to receive a cheerful message at Fletcher Hill, Greenfield, N.H., 03047. — **Max Seltzer,** Secretary, 60 Longwood Ave., Brookline, Mass. 02146; Leonard Levine, Assistant Secretary, 519 Washington St., Brookline, Mass. 02146

19

A nice note from **George Michelson** — "The enclosed note on the death of **Bill Banks** will no doubt interest you, and I am sorry to be the bearer. As for myself, I keep going, am still on the job every day, and keep my hand in communal affairs. Only recently we moved to an apartment for easier living and fewer responsibilities. It has worked out very well after the trauma of disposing of the accumulation of many years."

Madeline W. Banks, Bill's widow, also wrote of her husband's death on September 28: "He had not been well for sometime but was able to lead a normal lazy life. During the past few years we have spent quite a bit of time in Bermuda and on Cape Cod, where we had a very pleasant summer. After a short visit in the hospital the end came rather suddenly and very peacefully. I remember so pleasantly our visit with you in Florida several years ago, a dinner party with you and your wife and a rather gay affair with Mary and **Arkley Richards**. Wonderful memories."

The newspaper report stated that William H. Banks, age 78, died September 28 at Portsmouth, N.H., Memorial Hospital. He was retired President and Chairman of the Board of Macallen Co. of Newmarket, N.H., manufacturers of mica components for industrial machinery. He was a member of the Federal Fire Society of Portsmouth, a 50-year member of Prospect Lodge of Roslindale, Mass., and a member of the Board of Directors of Portsmouth Memorial Hospital. He left his wife, one son, and three daughters.

The latest list of '19 members still living shows 163. Your secretary plans to send out around 20 return cards for each issue in an attempt to get news from as many of our class as possible this coming year. Please send in the return card with something about yourself or other classmates. Best wishes for 1976 to the class. — **E. R. Smoley,** Secretary, 50 East Rd., Apt. 11E, Delray Beach, Fla. 33444

20

A happy and healthful New Year to you all. The accompanying picture of our reunion group was taken by **Al Burke** as we disembarked from the cruise launch that took us around Boston Harbor, before our Pier 4 class dinner. See how many you can identify or, if stuck, ask me for a listing of names.

Welcome word from **Dusty Miller** of 1019 W. Mission Ln., Phoenix, Ariz., tells us that the Millers are still traveling the world, recent countries include Egypt, Turkey, Israel and Mexico. Dusty related the good news that **Skeetz Brown** is in somewhat improved health. He commends the success of Al Burke and **Perk Bugbee** in attaining such a high percentage of Alumni Fund participation.

Jim Wolfson writes to announce the birth of a grandson, Adam Jay, in California, which gives him and Gertrude an excuse for visiting the West Coast. Speaking of California, while visiting our daughter there we had an opportunity to have a telephone visit with **Toots Kinghorn** who is at 26392 Isabella Ave., Carmel Point, delightfully situated for a glimpse of that beautiful Carmel Beach and Bay. Toots and Elvira were chipper and enjoying good health and the good life.

John DeMeulanaer of Dorchester, Mass., expresses himself succinctly in just two words, "happily retired." . . . **George Wilson** writes, "Since my wife, Ruth, died, I have been keeping active with several retired senior citizens' groups — bowling, traveling, etc. and keeping up my main hobbies of mineral collecting, bird watching, oil painting and metal detecting. Never a dull moment," says George.

From Rollins College, Winter Park, Fla., comes word from the president that the board of trustees has named **Ed Burdell** Dean Emeritus of the College and Professor Emeritus of Sociology: "In recognition of his distinguished service to Rollins College in particular and in gratitude for his leadership in American and international higher education." A further honor to this distinguished educator who has done so much to add luster to our class is his membership in the Book-A-Year Program, the result of an anonymous gift to the College which provides for purchase by the library of a book each year in which Ed's nameplate will appear. Speaking for the class, we offer heartiest congratulations for these signal honors.

Francis Sears died on November 12 in Hanover, N.H. He was Appleton Professor of Natural Philosophy Emeritus at Dartmouth College, and had served as Chairman of their physics department. He held a master of science degree at M.I.T. and taught at the Institute for 30 years before going to Dartmouth in 1955. Distinguished for his prolific work as the author of elementary and advanced physics textbooks, his *Principles of Physics* sold millions of copies all over the world. With the noted physicist, Peter Debeye, he discovered the phenomenon known as the Debeye-Sears effect, a physical property of light involving the interaction of sound waves and light waves in transparent material. Professor Sears was a Fellow of the American Physical Society and was President of the American Association of Physics Teachers and, later, treasurer of the association. He was a member of the Optical Society of America and the American Society for Engineering Education. He is survived by his wife, Mildred. Francis' educational achievements were much admired by his classmates. He was a consistent and generous donor to the Alumni Fund, a distinguished and loyal classmate. He will be missed by us all.

As these notes go to press, a very pleasant phone call was received from "Pink" Salmon, '26, to tell about his recent visit to **K. B. White** at his castle home near Paris, France. Pink assures us that K. B. hasn't changed a bit. Still exceedingly active, he was about to conduct a two-week management seminar. He and Denise showed the Salmons around their fabulous Chateau d'Arthies, crammed with magnificient antiques and surrounded with extensive and beautiful gardens. It is good news, indeed, that our popular classmate and his charming wife are in good health and continue their active and productive life. We salute them! — **Harold Bugbee**, Secretary, 21 Everell Rd., Winchester, Mass. 01890

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Two good letters came in from Marianne and **Grant Miner** of Los Altos, Calif., in early October. Quoting Marianne: "We have been

A successful 55th Reunion for the Class of 1920

Come to the Fiesta!

Warren Henderson's, '33, recommendation for the M.I.T. Fiesta was in the form of these pictures from last year. "Some of our more intrepid alumni attempted roping the wild bull," he said; while others watched and ate fine paella at La Morena, the bull fight restaurant.

The M.I.T. Club of Mexico City has cordially invited all alumni to attend its annual Fiesta in Mexico on March 11, 12, and 13 — the 28th of a famous series of travelogue entertainments.

President Enrique García-Corona, '66, has released the tentative program and has asked prospective attenders to address the club for details: Apartado Postal 31, Fracc. La Florida, Estado de México, México, or telephone 562-17-73.

Plans include the traditional get-acquainted luncheon at the University Club, colorful market tours, a guided trip to Teotenango in Tenango del Valle, the latest archeological discovery, with luncheon at Jajalpa, the home of Hector Orozco, '45, and Mrs. Orozco. Modern life will be encountered at the Bazaar Sabado and there will also be time for visitors to do their own sightseeing. A secret event — a Great Kermess — has been added as a surprise ending for the Fiesta.

The cost is $130 per person including three meals and transportation to all events. Alumni from classes of 1950 and later have been invited as guests in the homes of Mexican alumni.

A four-day post-Fiesta tour at an additional $150 will include the gorgeous colonial capital city of Morelia, the nearby lacquerware center of Pátzcuaro and the lake of the same name where natives in pirogues wield picturesque butterfly nets off the island of Janitzio to catch tasty *pesca blanca.* — Carole A. Clarke, '21, Executive Secretary-U.S.A., M.I.T. Club of Mexico City, 608 Union Ln., Brielle, N.J. 08730

mired in intensive domesticity — wallpapering, painting, installing new kitchen cabinets, sink, and a gay, thick wonderful rug in the kitchen." Grant: "That was my swan song — no more construction projects for me. However, Marianne said it was worth living with me for 43 years to get that carpet. Now she cooks in her bare feet." Grant is continuing to hunt for more information about his kinsman, Billy Miner, the highwayman. In this search he recently dropped in at the Wells Fargo Bank History Room in San Francisco and came home with a copy of "Old Time Stage Coach Hold-ups." The article relates how stage coach robbers generally led short lives, but Billy Miner was an exception. "Holding up his first stage in Texas at the age of 17, he held up an express train in Georgia at 70, covering over 50 years of deviltry." But in all those years, he never shot a man. What a kinsman! Grant goes on to tell that he is doing some consulting work for the Zenitaka Corp., but with no construction planned for the immediate future. He had a recent letter from John Burr Starkweather, '22, who told about falling off a ladder while painting the side of his cottage on Friday, June 13, and crushing his right shoulder. However, John is back playing golf again.

In a recent telephone call, **Helen St. Laurent** reported she was back in Manchester, Conn., after her summer in Maine. Late in October she attended the M.I.T. Club meeting in Portland, Me., with Theona and **Al Genaske**. She informed me that Graciela and **Heller Rodriguez** had an auto accident south of Savannah while they were returning to Florida. The rear end of their car was smashed; fortunately, neither of them was hurt. The driver of the other car was a 17-year-old girl, driving barefoot. The accident held them up six days; they sold the wreck of their car and rented another to get home to Tampa.

Helen asked for the address of the **Bill Roses**. My last address is Peterborough, N.H., but Helen thinks they moved to North Carolina. How about it, Bill?

Samuel Lunden, our Assistant Secretary, wrote that in September he and Leila took a Mediterranean cruise on the Oceania out of Southampton, stopping at Athens, Kos, Istanbul, Palma and Lisbon. On their return to England they visited Plymouth as a part of their celebration of the Bicentennial year. With Plymouth as their home base they toured the South Coast including Devon and Cornwall. Since Plymouth was such a beautiful spot, Sam wrote, it was hard to understand why our Pilgrim fathers (even under persecution) left Plymouth for the hardships of a strange land.

I am sorry to report the death of our classmate, **Arthur W. Morse** of Stamford, Conn., on March 7, 1975. The sympathy of the class is extended to his family. — **Sumner Hayward**, Secretary, 224 Richards Rd., Ridgewood, N.J. 07450; **Josiah Crosby**, Assistant Secretary, 3310 Sheffield Cir., Sarasota, Fla. 33580; **Samuel E. Lunden**, Assistant Secretary, Lunden and Johnson, 453 South Spring St., Los Angeles, Calif. 90013

22

It is hoped that we may boast occasionally about Buffalo weather, which allowed us to play golf up to the middle of November under clear sunny skies. . . . **Abbott Johnson** has written from Muncie of golfing at Crystal Downs Country Club, Crystal Lake, Michigan. His description of the lakes, rolling countryside, and woodlands is musical and makes you want to come. He also invites us to play at Muncie's Delaware Country Club. He will be in Phoenix Towers, Ariz., until April 15 and welcomes classmates anytime.

The floating bridge off Seattle which **Horace W. McCurdy** built years ago is pictured on sugar packages in many restaurants. Mac writes that he and Katherine have put away their yacht, *Blue Peter,* and will

spend the winter in the South. They recently gave a new fiberglass eight-oared shell to the Institute. . . . **G. Dewey Godard** reports 76 years of good health and finally a five-week trip to the Salem Hospital. He is now O.K. under restrictions. . . . **Dwight F. Johns** of Oakland, Calif., reports that he finally has a great-grandson to play with his 4-year-old great-granddaughter.

Francis J. (Pat) Laverty retired in July, 1965, as Superintendent of Public Works in Ithaca, N.Y. He also retired as Lieutenant Colonel of the Air Force. After some health problems in late 1972, he moved to Boulder, Colo., in July, 1973, and has felt greatly improved. . . . **Martha Eiseman Munzer** taught a teacher's workshop at the University of New Mexico this past summer and is now teaching a course at the Mamaroneck High School on community development. She is on the Board of Conservation Advisory Commission for her town and is Chairman of the Village Land Use Study Committee. Martha has always enjoyed being busy.

Vernon Whitman of Rochester comes to Buffalo periodically with his wife to visit her sister who lives in our apartment building. Knowing of our M.I.T. relationship, they invited us all to dinner a few weeks ago. Vernon announced that **Bill Elmer** would be visiting him soon while giving a Colloquium at the University of Rochester Institute on Optics entitled: "Optics of Reflector Design." Bill is our talented classmate specializing in music, history, and other fields that he fancies interesting. He calls himself an educated blacksmith as he reviews his book, *The Optical Design of Reflectors*.

Bill writes: The book "is a codification and compilation so to speak of my many years as a consulting reflector designer. I have worked with a very great many companies, both great and small, and designed reflectors for lights that have been used on miner's hats, in the depths of the ocean, and on the surface of the moon. It seems remarkable to me that there is no discoverable volume on this subject anywhere in the world, and even more remarkable that there seems no likelihood of a competitor in the near future. The book, which I wrote so that all the lore I learned and devised in my work would not become a lost art, has had a chequered career. It was rejected by all the publishers I could think of, about 18 or 20 in number, so I proceeded to 'publish' it myself and to sell it in Xeroxed looseleaf form in pretty stiff covers. The result has been electrifying, to me at least: I have been selling it all over the world, from Australia to Barcelona. Such serendipity!" We are sure he has a great future for us all to applaud.

Our notes on changes of address have disappeared, but our notes of sympathy have increased. We are sorry to report the death of **Arthur L. Flanders** in September. He was born in Lowell and settled in Houston, Tex., in 1930. He is survived by six grandchildren, one son, one daughter, and one great grandson. Our sympathy has been extended to Hazel. — **Whitworth Ferguson,** Secretary, 333 Ellicott St., Buffalo, N.Y. 14203; **Oscar Horovitz,** Assistant Secretary, 3001 South Course Dr., Pompano Beach, Fla. 33060

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Norman Weiss of Tucson, Ariz., was designated a Distinguished Member of the Society of Mining Engineers of the A.I.M.E. "The distinction is bestowed for outstanding or notable contributions to the technology or professional activities encompassed by the Society . . ." The installation took place at the Minerals luncheon of the society on September 12, 1975, in Salt Lake City, Utah. We congratulate you, Norm, on this well deserved recognition! . . . We hear that **Howard A. Lockhart** of Haverhill, Mass., has been most active in many community activities. A past president of the Haverhill Rotary Club (1961-1962) he served as secretary of that club for 10½ years. He was honored as a Paul Harris Fellow, the first award in the 62-year history. Retired now for some ten years, Howard still operates as a public utility consultant.

Although post-retirement awards have not come my way, I too have been active this past winter and summer as a consultant in the ball- and roller-bearing field. My last job was as a consultant to the Magnavox Co. of Fort Wayne, Ind., on the bearing requirements for their shipboard terminal equipment for the communications satellite system. It seems that this system of communications can be a real money-saver for reliable radio contacts ship-to-shore and vice versa.

We are extremely sorry to learn of the death on August 26, 1975, of **Samuel T. Dubitsky,** architect, of Barrington, R.I. Sam was born in Fall River, Mass., and lived there for much the greater part of his life. After graduating with us, he was an architect for more than 50 years and designed the first science building at Brandeis University in Waltham. Other buildings he is responsible for include Temple Beth-El, the Ziskind Auditorium, the Congregation Adas Israel Synagogue, the Jewish Home for the Aged and the Tansey School, all in Fall River. He is survived by his widow, a son, Judge Ira Dubitsky; and two daughters, Harriett of Miami, Fla., and Sylvia of Barrington, R.I. — **Thomas E. Rounds,** Secretary, 990 A Heritage Village, Southbury, Conn. 06488

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We regret to report the death of **Simon Kirshen** on October 24, 1975, in Brookline, Mass. Cy was a little older than our average, and was in the Coast Artillery in 1918. He earned his S.B. in general engineering and spent some years with the Massachusetts Department of Public Works, eventually establishing his own office as a consulting engineer in Boston. He was a member of Sigma Omega Psi, the Electrical Engineering Society, and Massachusetts State Engineers Association.

George Riegl passed away on June 24, 1975, in Carmel, Calif. He was born in Czechoslovakia and received his degrees at the Technical University of Prague, attended University of Chicago, and spent one year with us. In 1945, he became Director of Engineering Services in the Pittsburgh office of Czechoslovakia Metallurgical Works. He wrote a number of articles on engineering-management-distribution problems.

We overlooked an April report on the death of **Gordon Wheeler** in Troy, Ohio on March 18, 1975. Gee lived in Boston and prepared at Chauncy Hall School. His degree was in business administration and he was a member of Alpha Tau Omega, WoopGaroo, Baton, Musical Clubs and circulation manager of Voo Doo. In 1948 he was with the Sentry Company, Foxboro, Mass., but later was District Representative for C.I. Hayes, Inc., LaGrange, Ill.

The Class regrets the loss of these members and extends its condolences to members of the respective families.

On a happier note, **Paul Blampied** writes: "After completing three trips around the world, I am staying in the U.S. (Squantum, Mass., in summer and Boynton Beach, Fla., in winter.) Inflation and widower state are factors. Although retired from Johns-Manville for seven years, I'm still invited to sales meetings. Terrific — old friends and expense account. A retiree misses them most!"

Maurice T. Crowell sends a note, apparently from Milwaukee, Wis.: "I continue to play golf three or four times a week at my home course here, Tripoli Country Club. In the winter we usually alternate each year for two or three months in Florida or San Diego."

Luis A. Ferré, former governor of Puerto Rico and life member of the M.I.T. Corporation, has been named new Chairman of the Council for the Arts at M.I.T. by President Wiesner. He succeeds **Paul Tishman**, the noted New York collector of African art, who was the Council's chairman since its inception in 1971. Paul had not wanted to resign until a strong and dedicated successor was found.

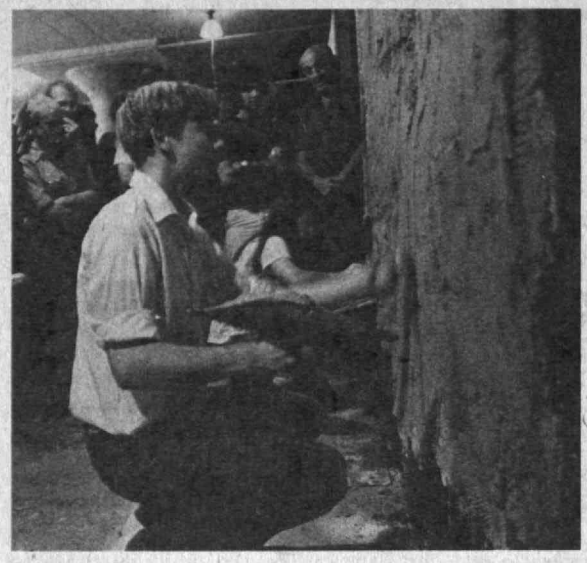
Herb Stewart, George Knight and your scribe attended the Alumni Advisory Council on November 3, which marked the beginning of the Association's efforts to determine how the Alumni could work more productively to meet M.I.T.'s financial goals and its commitment to relevant, superior education in science and engineering, management, economics and architecture.

M.I.T.'s athletic facilities are being used this year by more people than ever before in the history of the Institute. One of the goals of the Institute's Leadership Campaign for $225 million in private support is a center that would house an indoor skating rink, replacing the existing outdoor rink, a field house and a special events center for commencement, alumni convocations and other large gatherings.

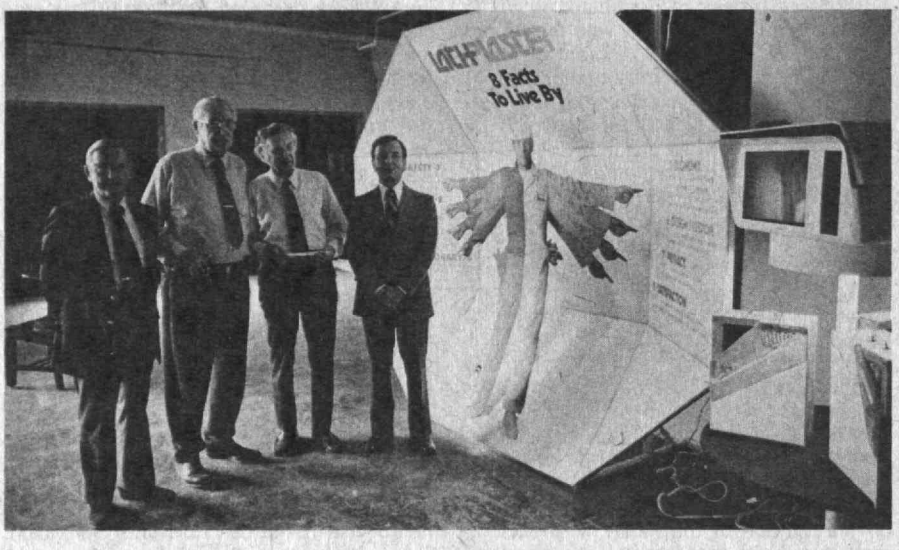
Class treasurer, **Ray Lehrer**, returned from ten days in Russia on October 28. He stayed in two of the finest hotels in Moscow and Leningrad, found them clean, food good, but the menu limited. There appeared to be no unemployment and the people seemed content. Fortunately, Ray missed the heavy snow storm that buried the following group. Your secretary must comment that he found conditions quite the reverse during his eight months in 1930, living in Kharkov in the Ukraine. — **Russell W. Ambach**, Secretary, 216 St. Paul St., Brookline, Mass. 02146; **Herbert R. Stewart**, co-Secretary, 8 Pilgrim Rd., Waban, Mass. 02168

25

It may seem rather late to report further on the 50th Reunion, but those who could not attend may be interested to hear of the many M.I.T. people who joined us. Many representatives of the M.I.T. administration were with us, and officers of the Alumni As-



". . . the nuts and bolts aspects of this business," he called it when C. George Dandrow, '22, consultant to the Northeast Lathing and Plastering Promotional Bureau, Inc., brought a team of lath-and-plaster experts to the Department of Architecture last fall. In two days of demonstrations, members of Boston Plasterers' Union No. 10 showed students how lath and plaster work — and gave classes in building construction a chance to try it for themselves. "Nothing can replace quality materials," said Mr. Dandrow, "even in a country whose economy seems more and more to be built on planned obsolescence." The photo below shows Mr. Dandrow (second from the left) standing with Professor Albert G. H. Dietz, '32 (second from the right), with industry representatives and the exhibit which they brought to Professor Dietz's M.I.T. classroom. (Photos: Roger N. Goldstein, '75)



sociation attended also. In addition, two friends known to many of our classmates accepted our invitation and were present at the banquet. Professors Raymond Douglass and Karl Wildes added much to the enjoyment of the occasion and we are indeed grateful for the opportunity to meet with them after so many years.

Evelyn and I had a most enjoyable visit to the British Isles. After seeing some of Scotland we toured through parts of southwestern England and portions of Ireland. We had some time in London but the stay there was much too short to accomplish all we desired.

The Boston *Herald-American,* (November 7, 1975), carried the notice of the passing of **Malcolm S. Blake.** Mal was born in Newton, Mass., graduated from Bowdoin College in 1924, and joined us at M.I.T. for the final year. He received his S.B. from Course IV. He was with the National Fire Protection Association in Boston before going with the Bethlehem Steel Co. by whom he was employed in an executive capacity for 25 years before retiring in 1965. Since that time he has resided at 233 River St., Norwell, Mass. Mal leaves his wife, Constance (Bailey) Blake, two daughters, a brother and a sister.

Word of the death of **John Albert Carnagey** in Badin, N.C., on September 20, 1975, has just arrived. John got his M.S. in chemical engineering with the Class of 1925.

The full cooperation of you is necessary if these notes are going to be newsy. Let's hear from you soon. — **F. Leroy (Doc) Foster,** Secretary, 35 Woodland Way, P.O. Box 331, No. Chatham, Mass.

26

"About that Nor'easter. We old timers — the ones with Stockholm tar in our veins — call it a Nothe-easter," says John Drisco, '27. "I'm told by 'them as has been there' that to avoid confusion between the two compass directions, especially with the wind howling and sails slatting, it was *Nor*'west — but *Nothe*-east. In between was just plain Northe."

We wonder if perhaps John with his Maine heritage may be recalling the sea terms from down east. We have an old (1936) Sea Scout manual and quote from it, "Now I suggest that we use the short sea-going pronunciations: Nor for the North, Sou for the South, etc."

A little local research from Capt. Bibb Hillier, dean of local lobstermen and the one always quoted by the *Gloucester Times,* has settled the question: John was unquestionably correct with "Nothe" as relates to the New England coast. However, when sailing on a Canadian fishing boat, Capt. Hillier found that the Newfoundlanders always referred to Nor'east winds. But we are New Englanders, and from now on it's Nothe-east!

During the week of November 7 classmates **Chenery Salmon, Bob Dawes, Bill Meehan, Don Cunningham** (chairman) and your secretary gathered to finalize our 50th Reunion plans. Joe Martori of the Alumni Office was our mentor. Our host for dinner was Warren Seamens of the M.I.T. Historical Collections, a place you must include during your reunion visit. Don Cunningham has written a summary of our meeting which contains so many items of interest we are giving it to you in detail:

"We agreed to add regional committeemen who will impress the importance of our 50th on their friends in their region. When our letterheads are available, we will write to each and notify them of their honor and responsibilities.

"We discussed the cardinal color of previous 50-year jackets and agreed we liked the darker-toned ones. With his textile experience, we have delegated the selection of fabrics to Bob Dawes.

"We reviewed six or seven booklets from other 50-year classes showing names and addresses of their classmates. We have 472 addresses and 428 active members. Out of 847 graduated, 308 are deceased,

539 living, and 67 with no address available. We hope to send booklets to all whose addresses we have. The attendance for our 40th reunion was 170 (13.4 per cent of '26 alumni) and for our 45th, 158 (13.9 per cent).

"The women's dormitory, McCormick Hall will be available gratis starting Wednesday, June 2 through Sunday night, June 6. A small number could be accommodated for Monday night, June 7. Classmates should arrive during the day, Thursday, June 3, to attend Pops at Symphony Hall that night. Our class will have a reception at the President's house before Pops and we can leave directly by bus for Symphony Hall. We will include a reservation form to be returned to Chatham Bars Inn in our mailing. Also a card to be returned to the Alumni Office requesting dormitory rooms. The tickets for Pops will be part of the mailing for Alumni Day, Friday, June 4, until noon Sunday, June 6.

"At Chatham Bars on Friday evening, **George Smith** will ask Edna (Mrs. **Argo) Landau** of St. Louis to give one of her taped slide entertainments and to bring a second one along should we have bad weather. She gave an excellent show on our 45th. On Saturday noon is the Clam and Lobster Bake. Golf will be available all the time. That evening a banquet followed by dancing is planned. We will sorely miss **Frank Schreiner** as M.C. Let's have some suggestions. The finale will be a Sunday luncheon after which our classmates can go their way and take advantage of Bicentennial activities." Cherrio. — **George Warren Smith,** Secretary, P.O. Box 506, Pigeon Cove, Mass. 01966

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Joe Harris, who knows from experience how your class secretary sometimes has to scrounge for news, helps out with the note that he and Mrs. Harris are taking a London theatre tour sponsored by the Goodspeed Opera House of East Haddam, Conn., in January. Joe writes, "We look forward to seeing some of our old-time Shell London Office friends, most of whom, of course, are also now retired."

Walter Walker sends in a capsule report of how he now spends his "leisure" hours in retirement: "Keep household functioning. Repair car (1967 Buick Special). Radio amateur — active on low frequencies keeping daily skeds with my old buddies spread over U.S. and some foreign countries. Attend church with wife. Mow grass. Sweep snow. Feed birds and squirrels. Attend lectures (mostly technical). Peruse mail (mostly 'junk')."

When I mailed the copy for the December notes (in October), Christmas was so far off that I forgot to include holiday wishes. Let me now wish a happy and prosperous year to all the class. — **Joseph H. Melhado,** Secretary, 24 Rodney Rd., Scarsdale, N.Y.

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Last month we mentioned the possibility of holding a mini reunion of '28ers during the annual M.I.T. Fiesta in Mexico. Appropriately enough, the 1976 event will be the 28th Fiesta of the M.I.T. Club of Mexico City. You may have already received registration mterial in the mail. This year the Fiesta will be held March 11 through 13. There will be a post-Fiesta tour of the historical city, Morelia, and nearby Lake Patzcuaro. Those who have attended the Annual Fiesta in Mexico express only high praise and enthusiasm, so we hope you will be joining us for this special gathering. Be sure to mail your reservation promptly.

Our great celebration, the 50th Reunion of the class is only two years off and plans are well underway. It will be held on campus in Cambridge. Start making your plans now, get in touch with other classmates, and let's make this the best reunion ever! Meanwhile, **Jim Donovan** and our class agents, **Tom Larson** and **Charlie Worthen,** are hard at work on the traditional 50th Reunion Gift.

In a brief letter to Jim, **Arch Archibald** says that except for a trip to Nova Scotia and a date at the Lahey Clinic in Boston last January, he has done very little traveling this past year. He and Clara have stayed at home trying to get some things done on their five acres. . . . **Gerry MacGillivray,** visiting in nearby Waltham, was thoughtful to telephone Jim for a chat. Gerry has every intention of being at the 50th. . . . We are very sorry to learn that **Joe Gaffney**'s wife, Marie, died on September 26, 1975. She was stricken with a massive heart attack while she and Joe were visiting Joe's sister in Winchester, Mass. The Gaffneys lived in Hinsdale, Ill., and have a son, Joseph John. Sympathy of the class has been expressed to Joe and his family. . . . Judith (Mrs. **Benjamin) Miller** has returned from a trip to Egypt, Syria, Jordan and Israel as a member of the steering committee for American Professors for Peace in the Middle East. Prior to his death, Ben was a founding member and National Treasurer for the organization. — **Walter J. Smith,** Secretary, 37 Dix St., Winchester, Mass. 01890

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Laurence L. Waite has sent a note of appreciation for getting a birthday card from the Class of 1929, and he is well and leading a happy retired life in California.

Henry S. Muller, who operates a tree farm in Belmont, Ohio, has been having a rough time due to the recession. He states that this is the worst business slump he ever has experienced. . . . **John H. Tomfohrde,** who lost his job when the Boston Naval Yard closed a few years ago, has got himself a new job, as draftsman for the Standby System in Medford, Mass. John, who went to Somerville High School with your secretary has changed his residence. After being of the same house for over half of a century, he has moved from 52 Browning Rd. to 326 Broadway, both in Somerville. . . . **Carl W. Harris** reports that he is living happily in retirement in Sarasota, Florida. He has three married daughters who live in Hingham, Mass., Mystic, Conn., and Chicago, Ill., each having three children, thereby giving Carl nine grandchildren. His son, Carl Jr., who lives in Boston, got married last September 12. . . . **Anthony J. Perry** who retired from the Corps of Engineers some years ago, has been busy doing consulting work. "Most of my recent consulting work which I have done has been in the western part of the United States. I have had no overseas work for a while. I hope to visit Cambridge next year on Alumni Day. Best wishes to all my classmates."

John H. Butler writes, "I have been retired for two years now and I enjoy it very much." . . . **Arthur A. Jones** writes, "Though retired, I still remain active in A.S.T.M. Standards activities, on Committee B-1 on Wires for Electrical Conductors. This gives us an opportunity for travel twice a year. This year (1975) the meetings were held in Washington, D.C., after which we headed south, all the way to southern Florida, visiting friends, wildlife sanctuaries, and points of interest on the way. The high point of our trip was a three-day visit at Okefenokee Swamp, in southern Georgia, which was so beautiful. We attend the M.I.T. Club of New Bedford, Mass., and see **Frank Mead** and his wife Mary occasionally. We are thoroughly enjoying our retirement." . . . **Frederic L. Bray,** writes, "Since Social Security payments cannot support the three of us — my wife Irene, my mortgage holder and myself — I am obliged to continue working. Everyone tells me how lucky I am to have my health and how sensible to keep working. Time will tell. Best Wishes to all." . . . Since his retirement of service, **Richard K. Opper** is just as busy in community activities. He lives in an old nine-room house in Walcott, full of precious antiques. He is president of Naugatuck Y.M.C.A. and Walcott Historical Society.

Where most of our classmates are either retired or about to be, **Thomas W. McCue** seems to be expanding his business activities. Tom is self-employed doing a variety of things such as national and international sales of commodities in steel, coal, oil and other items, acting as a broker. He also deals in a number of advertising periodicals, selling services of all kinds as far away as Taiwan. He is also studying part-time to improve his methods of operations. He lost his youngest brother last August who passed away suddenly. He sends his best wishes to all. . . . **Mrs. Herbert (Helen Mary) Walther** writes, "My husband, who also was from M.I.T., died of cancer last October. I keep very busy — mostly fighting a proposed super-highway which is planned to go

The second of a limited edition of Honeywell Strobonar flashes was presented to Harold E. Edgerton, '27, Institute Professor Emeritus, (right) by Robert L. Pennock, Vice President and General Manager of Honeywell Photographic Products for his pioneering role in the development of strobe photography.

Television Leadership, and the Power of Radio

Two unusual awards came to James R. Killian, Jr., '26, Honorary Chairman of the M.I.T. Corporation, late last spring:
— The first Marconi International Fellowship, whose purpose is to commission creative work that links science and engineering to the betterment of human life.
— An accolade — a "Salute to Dr. Killian" dinner — from the Advisory Council to National Organizations for his service as Chairman of the Board of the Corporation for Public Broadcasting.

The Marconi Fellowship — a $25,000 commission — came to Dr. Killian at a banquet of the National Academy of Engineering in Washigton on April 23. To carry out the commission, Dr. Killian has chosen Asa Briggs, Vice Chancellor of the University of Sussex, England, to study the social and human implications of the development of radio broadcasting. The Fellowship was created by Gioia Marconi Braga, the daughter of the inventor of radio, and underwritten by 15 industrial corporations.

The "Salute to Dr. Killian" evening consisted largely of tributes and accolades by public and television figures related to Dr. Killian's role in conceiving "public television" as Chairman of the Carnegie Commission on Educational Television in 1965-66 and, more recently, his service as Chairman of C.P.B.'s Board of Directors. □

The stars of "Zoom," a successful children's television program produced by WGBH-TV, Boston, for showing on public broadcasting network stations, made a special trip to Washington on May 14 to say their thanks to James R. Killian, Jr., '26, at a "Salute to Dr. Killian" dinner. The affair, arranged by the Advisory Council to National Organizations, was in tribute to Dr. Killian's role in creating today's public television.

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through our small village, which we believe will be an ecological disaster. I have also joined many other residents in our community opposing the construction of a dam which would flood one of the most beautiful valleys in this part of the country, doing untold amount of damage to wildlife. I also garden, entertain, put on children's plays and am writing a book." . . . A nice note comes from **John Russell Clark** which reads, "Dot and I just returned from the Alumni Officers Conference at M.I.T. The program was excellent. It was nice to talk with current administrators, and update on the Institute's plans and programs. I had a nice chat with **Wally Gale** whom I had not seen for ten years. This year, I finished a four-year tour as a member of Visiting Committee for the Department of Aeronautics and Astronautics. It was very interesting and educational. I am glad to see the enrollment in that department increasing after several low years. The industry is shorthanded for young people with innovative ideas and concepts. Dot and I intend to stay in the Big 'D' (Dallas). It is a great country and good people in it. Being semi-retired, I have been doing consulting work for L.T.V. Aerospace Corp. in Dallas, the U.S. Air Force and the A.I.A.A. Will be glad to hear from any '29ers who happen to be in this area, particularly Course 16. Phone 214-361-4795. Regards to all." . . . For the past four years, **Sidney Darlington** has been an adjunct professor at the U.N.H. in Durham after his retirement from the Bell Tel. Labs. Last April, he was awarded I.E.E.E.'s Edison Medal "for basic contributions to network theory and for important inventions in radar systems and electronic circuits." He was also elected as a member of the National Academy of Engineering. Last spring he taught at graduate level a course on filter theory and design in the Electrical Engineering Department.

A brief note from the widow of **William S. Tyler** announces that Bill died in his sleep on September 16, 1975. Word comes that another '29er, **Ralph B. Atkinson,** has passed away. He was killed in an automobile accident on June 11, 1975. — **Karnig S. Dinjian,** Secretary, 6000 N. Ocean Blvd.-Apt. 14-E, Fort Lauderdale, Fla. 33308; (305)-946-0425

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Hopefully, you have received **Larry Barnard**'s letter of October 22, 1975, telling of the 45th Reunion plans. In case you missed the letter, here are the salient points — our reunion will be on-campus. We will be staying in Burton House "for free." Arrive any time after noon on June 1. Thursday night is the Pops, Friday is Alumni Day. The reunion will adjourn after brunch on Sunday, June 6. **Ed Hubbard,** Program Chairman, is planning a program for everybody — from golf to Boston Harbor boat cruises. Be sure to mark the date down — and plan to attend.

If it hadn't been for Larry's letter, your Class Notes wouldn't have amounted to much this month. No word from any classmates during the past month, nor have I seen any of you. Sally and I are heading for Florida for a few weeks and hope to see some classmates there. Unfortunately, we won't be able to stop "en route" as we are taking the cartrain down from near Washington, D.C.

John Swanton, with assistance from **Ben Steverman,** added these notes: "Ben suggests that with the 45th Reunion practically upon us, we ask our readers to update their addresses when responding to Larry Barnard's letter on the Reunion. Then we shall have a good up-to-date listing available for distribution in June. With all of the changes due to retirement moves, it is difficult to keep track of people.

"Louise and I have just returned to Newton after being at our place in Maine since May. I saw **Bob Leadbetter** in August at the Bath, Me., Marine Museum field day. He was there with his daughter, and son-in-law who is in the ship model construction and repair business. Saw also in a Downeast publication that Bob was a skipper in the 24th Maine Retired Skippers Race. Didn't hear who won! Don't forget to send your Reunion cards back to Larry Barnard." — **Edwin W. Worden,** Secretary, 35 Minute Man Hill, Westport, Conn. 06880; **Ben W. Steverman,** Assistant Secretary, 260 Morrison Dr., Pittsburgh, Penn. 15216; **John R. Swanton,** Assistant Secretary, 27 George St., Newton, Mass. 02158

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Jim Harper recently reported to your Secretary with a very newsy and informative letter on the recent Alumni Officers Conference. Among those attending were Wendell E. Rearce, **Arthur Lowery, Arthur Marshall, Raymond Schaefer, Donald Whiston,** and of course Jim. . . . A nice note from Don Whiston relating travels since our Ber-

muda reunion that have taken him to London and Salt Lake City and a very busy summer on a consulting job reviewing the physical plant organizations of some 15 community colleges in Massachusetts. Don is also the author of an article "Waste by Formula" appearing in the November issue of the *American School and University* magazine. . . . **Robert B. Semple,** Chairman of the Board, BASF Wyandotte Corp., has been elected a Fellow of the American Institute of Chemical Engineers, in recognition of his professional attainments, particularly in the development of Monsanto's synthetic fiber activity and the modernization of Wyandotte's organization and facilities. . . . The Alumni Records Office has forwarded the following necrology — **Erwin O. Kruegel** in Washington, D.C., on August 12, 1975; and **Oliver H. Scharnberg** in Westwood, Mass., on October 20, 1975. Our sincere sympathy to their respective families. — **John W. Flatley,** Secretary, 6652 32nd St., N.W., Washington, D.C. 20015

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Top billing is the Class of 1933 Mini-Reunion in Mexico City on March 11 through 13. See announcement and my photos from last year on page 104. Last year we had a marvelous time watching a few of our more intrepid alumni riding the horses at La Morena and attempting something like roping the wild bull. There is still plenty of time, even now, to make your wants known. Most of you will already have made up your minds.

I have no word from **Bill Baur** as to the response from class members yet. Bill spends part of the summer in Amherst, N.H., at the home of his daughter. Earlier this year, Bill and Claire drove 50 miles to see us and mentioned having been to Bogota. I had to ask what he was doing there. It seems that he belongs to "Schlaraffia," a world group of men of German extraction. It is in no way political, but instead devoted to, "strictly social and dignified horse-play." It's something when a sensible man like Bill will go to Bogota in late summer. Bill and I have been friends for 45 years; he runs the mini for his class.

There is a dearth of news from the faithful this time, a condition which seems at times to be chronic. **Jim Turner** is shedding his mantle as Class Agent. He and Edna are well, and I wish him luck.

We seldom hear from the women in our class, so I was pleased to hear from **Kelly** (Mrs. Peter) **Geddes,** who announced that she attended the last Alumni Day. The Department of Architecture sponsored a symposium for their alumni, at which Kelly had a great time, and wants to do it again. When we were students, the architects were isolated over on Boylston St., and knew very few of us in Cambridge. But of course they did know many students in other classes. The original reason for her letter was to obtain **Chuck Thumm**'s address. She and her husband chanced to stop at Chuck's ranch in Arizona, not knowing that Chuck was a classmate. I have never heard from Chuck! How come?

John Rumsey cut off the bottom of the mini application, and penned me a shorty. "No great news, except that we went to Soviet Russia, on a strictly pleasure trip."

Golf Is "A Little Quiet" for Bill Jones at 70

Wilfred V. Jones, '31, thought ("if you don't mind my saying so") he could beat them, and he did: the four top-ranking 70-year-old-and-over tennis amateurs on grass and clay courts. That makes Bill Jones the nation's top 70-and-over tennis-player, and during an interview late last fall, Dave van Dyck of the *Chicago Sun-Times* found Mr. Jones "loaded with glee over his new-found athletic fame."

Mr. Jones retired four years ago from his labor relations job for the state of Illinois, and only then did he begin to take sports super-seriously. He's always played tennis and squash, but now he works harder at them — and at keeping in shape generally. For two weeks before the championships last fall, he spent over an hour a day with a ball machine and jogged one mile before and after each ball-machine session; and before the interview with Mr. van Dyck, Bill Jones had spent the morning picking apples. He's also working on a book on labor relations, the field in which he worked for most of his life after graduating from M.I.T. in electrical engineering.

Bill Jones finds tennis "the perfect retirement sport. . . . Golf is a little quiet for me," he told Mr. van Dyck, "and I don't go in for that 19th hole." At age 70, he "feels great." And "about all I do is play tennis," he told Mr. van Dyck. □

John has just moved, but still lives on Wing Lake (Detroit area). . . . **Bill Sheppard** writes that he and his wife have spent three of the last seven years in Mexico, and that Mexico City is no more Mexico than New York City is the U.S.A. I had to tell Bill that he missed the point: we are using the Fiesta as an excuse for a reunion.

Once again, **Dick Morse** makes the news: this time the press announces that Dick has been appointed by President Ford to the Energy Research and Development Administration. This makes three presidents for whom Dick has served. Dick is also President of the M.I.T. Development Foundation. At a time when many of us are retiring, Dick is taking on more and more. . . . From **Ellis Littmann** comes a short note, telling of a visit he and Roz made to San Diego, the LaCosta resort, and then Scottsdale, Ariz., for a business meeting. Ellis said that he had little time to see classmates, but will later on another such trip. Ellis sent a photocopy of the current *Iron Age,* with our own **Ralph Cross** on the front cover. It seems that Ralph wrote an interesting article in that issue, though no details. Ralph sure gets around. Not many make the front cover of anything, business or otherwise.

Have you people noted that there have been no address changes lately? We had for years a card file of all classmates showing the address, course, scholastic achievements, and so on. Now, we have a voluminous copy of the class roll, active members only, and none of the information above.

We still receive notices of those who have passed on. **Charles E. Miller,** of Philadelphia died on April 3, 1975. We have no more details. . . . **Norman Levinson,** Institute Professor and one of the country's top mathematicians, died October 10, 1975. Norm was a remarkable man in many ways. His biography appeared here when he was made Institute Professor. I have written to Mrs. Levinson in the name of our class, a painful duty, especially for one so close to us all. — **Warren J. Henderson,** Secretary, 1079 Hillsboro Beach, Pompano Beach, Fla. 33062

34

News is slim this month, and would be slimmer if I hadn't decided to hold off last month with the following letter from **Charles F. (Fred) Barrett, Jr.** As you will see, he has really made a switch in life style.

He writes, "We have just embarked on a new phase of our retirement life, and I am writing this from our first stop after leaving. We have sold our home in Saratoga Springs and are using our Holiday Travel Trailer for full-time living. We do, of course, have to keep some anchors out such as mailing address (R.D.1, Box 150, Rexford, N.Y. 12148), which belongs to our daughter. She will forward our mail whenever we are set long enough to receive it. Also, for the summer and early fall months, we will park our trailer in Speculator, N.Y., where our older son has our old summer home and some two acres of land.

"This will be the fourth year we have headed for Florida to sit out the cold weather and the first time we have headed directly there. Twice we went by way of Boulder, Colo. (some detour! — R.M.F.), where our younger son lives. This way, we have seen nearly all of our great country except the West Coast, Nevada, Idaho, and Montana.

"Amalia and I decided on this way of life because our four children are all established for themselves and independent of us, and because we enjoy the out-of-doors life which travel-trailering gives. As an added bonus, we have met many interesting people in our campground stays."

I must say I have to admire someone who can cut themselves down to that scale of living. We accumulate so much in following our hobbies that paring down to that extent seems impossible.

At least each fall some members of the class of '21 round up some Lower-Cape alumni for a luncheon get-together. This year I got the word to **Ralph Brown, Ray Jewett,** and **Herman Ausin.** We had a pleasant meal, in the course of which I mentioned to Ralph we had to be in Amherst two days later for a state-wide Conservation Commissions meeting. Since he and Ann were going back to Wilbraham (they still divide between there and South Yarmouth), they invited us to spend the night with them. He ended up having car problems and taking the bus out but we drove Ann and when we arrived late in the afternoon, Ralph had two tremendous loaves of bread in the oven!

From Amherst we wound up with **Ted Taylor** and Winnie in Eliot, Maine (just up from Kittery). They will be leaving soon for their annual trip south. This time they're starting at an island off the coast of Yucatan and will end up eventually further north in Mexico where they have spent past winters. — **Robert M. Franklin,** Secretary, Satucket Rd., Brewster, Mass. 02631; **George M. Bull,** Assistant Secretary, 4961 Allan Rd., Washington, D.C. 20016

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Bernard Whitman was named Magician of the Month by *MUM,* the official publication of the Society of American Magicians. Here are excerpts from the article accompanying the announcement: Bernard went to work for Chance Vought Aircraft in Connecticut after graduation, starting as a structural engineer. He became Chief of Research in the Experimental Dept., and during World War II helped develop the famous Corsair Fighter. Later, when Chance Vought merged with Igor Sikorsky's company, Bernie worked directly with him on the original helicopter. In 1945 he returned to M.I.T. and worked in the Draper Lab. In his spare time he was pursuing his interests in magical shows and developed the Fu Ling Show so successfully that he left M.I.T. in 1955 and took the show on the road, but not before marrying his secretary and assistant in the show, Jeri Hollowit. By 1969, Bernie had earned his master's degree in industrial education from the University of Maine, was head of the vocational training program in the Weymouth schools, and well on the way to becoming a national authority on career education. In 1974 he was chosen as Teacher of the Year. He's retired now and lives at 788 Forest Rd., Marshfield, Mass. 02050.

Edward Woll, another helicopter man, has been awarded the American Helicopter Society's Dr. Alexander Klemin Award "for his years of leadership in design and development of jet engines and his prime influence in overall design of the U.S. Army's T700 turboshaft engine, to power advanced helicopters of the 1980's." Ed is Vice President and General Manager of the Group Engineering Div. of the General Electric Co.'s Aircraft Engine Group. He has been with G.E. since 1946. . . . **Michael G. Kelakos** was recently awarded the 1975 Golden Lamp Award which is given annually to a graduate of the Hellenic American School in Lowell. Michael has recently retired after 25 years of distinguished service with the State Dept. He lives at 11 Algonquin Rd., Canton, Mass. 02021, with his wife, Theresa, and their two children.

Our class is proud of all its award winners.

Last May 16, **Sam Brown** wrote to me. It was his 62nd birthday and he said: "This month ends 29½ years for me at Coverdale and Colpitts, and two weeks from today I am retiring. [He ended as Chairman of the Board]. After a busy month of June, I expect that my part time consulting and four professional directorships will involve working an average of seven or eight days per month, which will leave me with plenty of time for golf and other things. Helen and I spent a 12-day golfing holiday in Puerto Rico last December and another one in Florida in March, with perfect weather both times." Doreen and I had a delightful day playing golf with Sam and Helen at Canoe Brook in July.

Those who were lucky enough to be at the reunion surely talked to **Bud Pflanz** and met his lovely fiancee Gloria, but I have been saving the letter he wrote to me in April because I wanted to print it at a time when there would be few distractions. Here it is: "Confused am I. I get correspondence relating to the reunion of the Class of 1935, but not a thing about the Class of 1935½. You all have sheepskins dated in June, whereas for reasons left unsaid, mine is dated in December. So you see, I'm of the Class of 1935½. However, as there probably are few of us, perhaps I should lower my standards and join you '35ers. That is if I can bring along my fiancee instead of a wife (who died years ago). When the army decided I was too old to crawl on my belly like a reptile anymore, I worked as a civilian for a while until my company decided they couldn't afford me. Since then I have been a 'househusband' keeping house for my three children until they all go away to college (still have a 17-year-old attending high school). So while you hard-working types are getting broad beams and ulcers, I get dish-pan hands and bruised ankles from being rammed by shopping carts in the aisles of supermarkets. As for your hand-written comment —while 'tis true I rowed during my freshman year, my six-foot 127-pound frame didn't contribute much toward beating the varsity. It did however contribute to a comedy routine; whenever we tossed the shell overhead it left the bow man, a shorty, (I was #2) hanging with his feet dangling. Yup, I'm planning to attend the 40th, God, my intended bride and my car tires willing." And obviously they all cooperated. Bud's address is 242 Grant Ave., Eatontown, N.J. 07724.

In early October, business took me to the Allentown area. I had contacted **John Brosnahan** in advance, who set up a golf date. We met the evening before for dinner and I stayed at his house, which gave us an excellent chance to get caught up-to-date after 40 years. His wife had gone with friends to their summer cottage for the weekend, John delaying his trip until after our golf. John is in his 40th year at Bethlehem Steel where he is Product Supervisor in their closed die forgings plant. He started in the lab as a metallurgist, began helping to solve field problems and moved into sales. He and his wife Josephine have three children, all grown and flown from the roost. Josephine, their daughter, lives with her State Department husband in Rabat, Morocco. Tom, the older son, got his doctorate at Tufts and has been living in Istanbul with his wife for the past year. They were returning home in November. Steve is single, graduated from the Rhode Island School of Design, took an extra year of study in Rome, and is working for Envision in Boston. This is a family with many artistic talents and there are examples all over the house. To me, the most interesting and really exciting were the sketches of members of the family which John himself had done along with some landscapes. I wish you could see them. As far as the golf was concerned, we had a good time even though it was overcast and misty. John had lined up two friends to play: Bill Komich and Walt Hofmann, '34, so a great time was had by all.

Doreen joined me in San Francisco during a recent business trip and we stayed with Edith and **Ham Dow** one night and then on to stay with June and **Brownie Brownell** on the Monterey Peninsula. It was great fun, with good weather, except for one day, and golf at the Dow's and Brownell's courses. It was my first time back in the Pebble Beach area after 16 years, but the closed peninsula area has not lost its exclusivity and charm. The Monterey Peninsula Dunes Course was a real thinking-golfers' paradise. I learned that Verna and **Gerry Rich** are now living in Los Gatos and Gerry is teaching. We had no luck at all in locating them.

The 15th Annual Class Golf Tournament has crowned a new Champion for 1975: **William J. Bates.** Bill ended up in a blaze of glory with successive rounds of 86, 86 which with his 21 handicap (and that will change) gave him net 65's against **Al Johnson** in the semi-finals and **Bob Flood** in the finals. Even **Ham Dow** would have had a hard time matching that one. Ham turned the cup over to me, it is being engraved and will be shipped to Bill to display for a year. It's going to be hard to win it away from him, I know. I had a chance to play with him at his course during the summer and he can surely "hang it all together" when the chips are down.

Now all you readers out there: this is a new year, make your Class Secretary happy and drop him a note. — **Allan Q. Mowatt,** Secretary, 61 Beaumont Ave., Newtonville, Mass. 02160

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Eight class members and their wives joined your secretary for a mini reunion in late October. Mary and **Fred Assmann** drove up from Pennington, N.J., Marian and **Tony Hittl** drove up from Pleasantville, N.Y., with their weekend guests, Betty and **Elliott Robinson**. Lillian and **Larry Peterson** drove over from Schenectady while Barbara and **Ham Migel** came from Rhode Island. Barbara and **Roger Krey** combined a parents' day luncheon at Northfield-Mt. Hermon and supper in West Hartland as a reason to come down from New Hampshire. Phoebe and **Frank Phillips** stopped by on their way to New Jersey from Vermont, where they are building a cabin and expect to build a house. Virginia and **Augie Mackro** completed the group and joined my daughter Martha and me.

Dorian Shainin reports that he has taken early retirement from the management consulting firm of Rath and Strong, Inc., and as of last July he became an independent consultant. He is busier than ever but more relaxed. . . . **Ariel Thomas** travels considerably as manager during construction of a secondary treatment plant for waste water in New Jersey and consultant to the Allegheny County Sewage Authority in Pittsburgh. . . . **Don Thompson** retired from DuPont in 1974 and he and Marguerite have settled on the ocean at Winter Harbor, Maine. He reports one son with DuPont, one with Stone and Webster. Number three, Ann, is a part-time teacher in Peeskill, N.Y. By the time you read this the Thompsons will have four grandchildren. . . . **Eli Grossman** is involved with actuarial work at Security-Connecticut Life Insurance Company in Avon, Conn.; his wife Vivienne, a

Hill: Helping A.C.S. Work for its Members

Henry A. Hill, Ph.D. '42, who has established a reputation as a sort of anti-establishment maverick in the American Chemical Society, will be the Society's President in 1977. He won by the narrowest of margins in a mail balloting of A.C.S. members late last fall.

Chemical and Engineering News describes Dr. Hill as "a pioneer in orienting the Society toward the needs and aspirations of the individual chemist member." Though he has been an A.C.S. member for 34 years, his interest in the management and policies of the Society dates from the early 1960s when, "for the first time, we had more chemists than we had jobs for them." A member of the A.C.S. Board of Directors since 1971, he remains "deeply concerned with the welfare of the individual chemist and with the critical relationships among the chemist, A.C.S., and the federal government."

No radical change is postulated, says *Chemical and Engineering News*, because Dr. Hill wants "no diminution of the things A.C.S. traditionally 'knows how to do well' " in order to give greater attention to the problems of its individual members. Dr. Hill's opponent in the election was Anna J. Harrison, Professor of Chemistry at Mount Holyoke College; the vote was 15,550 to 15,410.

H. A. Hill

lawyer, is with a Hartford law firm; and their son is in graduate school at Cal Tech studying applied physics.

Bob Sherman is chairman of the science division at Pristol Community College in Fall River, Mass., and chairman of a committee of the Mayflower Society which is overseeing the preparation of a series of genealogies of the first five generations of all descendants (both male and female) of the Pilgrims. . . . **Al Gray** writes that Exxon has not threatened to retire him despite the lull in tanker construction.

With his contribution to the Alumni Fund, (and to the class gift!) **John Myers** reports from San Francisco that he was married last March to Jean Erbeck, a fellow employee: "My bride and I have discovered that the third phase of our lives — after the children have been raised and are gone (two of hers and three of mine) — can be very enjoyable."

I regret to report the death on August 28 following heart surgery of **H. Page Cross**, an architect who came to M.I.T. after graduation from Yale. He maintained an office in New York and specialized in designing homes in the northeast and Virginia. He served in the Marine Corps in World War II — **Alice H. Kimball**, Secretary, P.O. Box 31, West Hartland, Conn. 06091

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Jack Robbins has retired from American Cyanamid and is now situated on a branch of Carter Creek, a mile from the famous Tides Inn at Irvington, complete with bulkhead, dock and a newly-acquired 28-ft. Pacemaker. Jack writes that his most serious decision nowadays is whether to go fishing or play golf and he can't remember when he has been as busy. His new address is P.O. Box 886, White Stone, Va. 22578. . . . **Al Woll** has been reelected to chairman and president of the Indiana State University-Evansville foundation for a third term. He also reports that his daughter, Susan, recently married Kenneth Eisdorfer of Long Island, N.Y., who is a chemical engineer from Washington University in St. Louis. Al's new address is P.O. Box 5446, Lawndale Branch, Evansville, Ind. 47715. . . . **John Fellouris** and Gioconda spent part of the summer at their home in Athens, Greece. They also traveled to Iran and visited Tehran and Isfahan. . . . **Rutherford Harris** has been appointed assistant to the president of Arkwright-Boston Manufacturers Mutual Isurance Co. and will transfer to the firm's corporated headquarters in Waltham, Mass., from Cleveland division where he has served as manager of the central region. He is also vice president as well as assistant to the president. — **Robert H. Thorson,** Secretary, 506 Riverside Ave., Medford, Mass. 02155; **Lester Klashman,** Assistant Secretary, 198 Maple St., Malden, Mass. 02148

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Akim Zaburunov wrote: "Just returned from Japan and Hong Kong. A quiet and peaceful life, everywhere you see marriages. In one of these marriages the new couple passed with a smile and after I took pictures the groom said, 'What do you say?' I said 'Good luck to you both' and to my surprise all guests, old and young, started to clap. They understood English and an old man approached me and said, 'I like you, let's have a drink.' I found, in general, if you treat Japanese people humanely, try to understand their life and customs, they pay you twice for your kindness."

Hilda and I have been visiting in the Pacific Northwest. In Seattle we saw some classmates who have applied 30-plus years of their careers to Boeing and the aero industry. **Bob Withington** summarized his experience succinctly when he said: "You might say we are now fighting off old age, but there is tremendous satisfaction in having been in the vanguard during an exciting, progressive and unique aerospace era." Bob is right. I can remember standing, during 1938-39, at Logan Field in East Boston, waiting to board a two-engine DC-3 to make the two-hour flight to New York where I would arrange a band for one of our proms. In those days, were someone to have predicted that, within our time, planes carrying more than 300 passengers would take off half-way around the world, and fly non-stop to Logan Field, he might have been fair game for the man with the butterfly net or the custodian of the looney bin. But now it is only 36 years later. All that has happened — and more.

Probably no one knows how many '39ers have contributed to this exciting part of this era. In California alone there are **Ben Badenoch, Woody Baldwin, George Cremer, Bud Croshere, Dick Feynman, Leonard Jaffe, Paul Sandorff, Sam Sensiper, Gail Swan** and others. In Seattle today's group includes **John Alexander, Jim Barton, Hans Bebie, Dick Loesch,** and **Holden Withington.**

Nancy and **John Alexander** have made their home on the shores of Lake Washington for these 30-plus years. They invited Hilda and me to dinner the same night that **Morrie Nicholson** came to town, and we enjoyed a most pleasant evening. John has majored in development projects at Boeing over the years. However, he has changed his sport from lacrosse to sailing, and he and Nancy enjoy their 38-foot ketch. John invites volunteers to help with such high-altitude chores as varnishing the mast.

Morrie Nicholson is a full professor and resides in St. Paul, Minn. Morrie's academic and consulting work fill his schedule. He was in Seattle to attend a seminar which is another way of saying he was on the rubber chicken circuit. I am sure he enjoyed being able to get away from that to enjoy Nancy's delicious dinner. Morrie's supply of good stories is bountiful and he kept us all highly-entertained during the evening. He mentioned that **Bob Plunkett** is also a full professor at the same university.

Jim and Mary Barton made a one-month trip to Europe and asked us to house-sit their glamorous home on the shore of Lake Washington. This gave us our chance to see Seattle classmates. Also, it gave their 8-year-old Collie, Bruce, a chance to educate me in his well-formed habit patterns. Jim continues active in the administration of Boeing International. He wedges in time for the Institute. And his neighbors seem to like him because they have been re-electing him Mayor of Hunts Point Community for the past eight years.

98 Per Cent Off On a Pre-Owned Computer

John D. Moorhead of the *Christian Science Monitor* says Adolph (Sonny) Monosson, '48, is "an unassuming man with a sly look in his eye." Friends know that this is a good description of a popular M.I.T. alumnus who is a pioneer of the used computer business.

The current inventory of American Used Computer Co. is estimated at $40 million (original cost value); that places it among the largest in a helter-skelter business whose growth rate is one of the highest in the U.S. "There is $54 billion in hardware out there," Mr. Monosson told Mr. Moorhead — plenty to support a lively "second-hand" business which International Data Corp. estimates at $250 million yearly. Mr. Monosson wouldn't talk to Mr. Moorhead about his share of that national market: "This is a private company, and it's nobody's business," he said.

The biggest problem may still be to convince would-be customers that there's a market in used computers. But there are other problems, too — typical of any business that deals with "pre-owned" hardware. Mr. Monosson bought the whole Memorex business when manufacturing ceased. But the company's service and maintenance operations ceased, too, and Mr. Monosson says the only market for the equipment now is in universities and laboratories "where people know how to maintain it themselves." The result is that a Memorex 40 central processing unit, original price $175,000, now goes for $3,500. — *J.M.*

Bob and Betsy Withington invited Hans and Austie Bebie, and Hilda and me, for dinner and the evening at their lovely lakeside home. Bob is a vice president at Boeing, has been an engineering and management leader in missile, aerospace, and airplane accomplishments, and his references to this were fascinating. Three of the four Withington children happened to be home for the evening and made stimulating company. One works on the Alaska pipeline, and the other two are such accomplished skiers that they are in the pool from which the U.S.A. chooses its Olympic teams.

Hans Bebie has been working alongside Bob and he told some mind-wakers as he referred to optimizing design methodology and to the work directed toward the company's near- and long-term goals. The Withingtons and the Bebies share a 36-foot sloop-rigged sailboat which is moored just alongside the Withington home, and both families sail in summers and ski in winters.

Dick Loesch received national publicity for his activities in connection with flight testing during this 36-year era. He and Peggy own a cottage on Vashon Island, in Puget Sound, and they find delicious clams and gweducks in their front yard at low tide. Their backyard harvest this year led them to have a "cider press" which is sort of a neighborhood party during which all gather around to help with the "press" and then share the apple cider and good fellowship.

Those of us who were not engaged, during this 36-year era, in such glamorous careers have been flying at other levels to attend more mundane careers which include my fertilizers business. Well, Hilda and I always say: "It may be manure to you, but speak kindly of it because it's bread and butter to us." I don't know what others in the class might say about their careers, but if they will write I can pass along the reports and the one-liners. Some of the glamorous and mundane careers include the following:

Bob Saunders made carpets. **Bill Brewster**: shoes. **Bill Babcock**: highways. **Dick Christie**: garbage disposals. **Wiley Corl**: six children. **Eli Dannenberg**: carbon black. **Dave Frankel**: radio tubes. **Harold Goodheim**: gloves. **Gus Griffin**: stronger concrete. **Gus Hunicke**: counting machines. **Manning Morrill**: black plastic cases to hold ladies' wigs. **Cris Rosas**: whale oil from hundreds of whales caught off the coast of Peru. **Bob Touzalin**: a hole in one plus, by the time you read these notes, more sitzmarks at Vail. **Sid Silber**: cookies by the millions, as he became one of the six foremost bakers in the nation. Classmates not named above are invited to send along some newsbits, comments, and should know that the *Review* especially welcomes glossy photos suitable for publication.

Bascom Emerson's friends will be interested to know he is in Denver, continuing his high-flying career. During undergraduate days Emmie excelled on the high-bar, in World War II he continued to be airborne, at Wright Field and elsewhere. Now he is in Denver, one mile above sea level. Emmie has headquarters in the Mahogany Halls of Gates Rubber Co. and still does high-flying via Lear Jet (a Gates subsidiary). Other Gates activities of interest to Emmie include operating a 35,000-head cattle ranch, and possibly the world's largest automated, multi-story chicken and egg production facility; plus making rubber goods such as fan belts for our autos and lawn mowers.

Meanwhile, back at the ranch, or as they say, back at the fountainhead, our class officers met in Boston. They didn't talk about 36-year space-eras or our careers, because the major topic was the coming M.I.T. Fund Drive. In due course we'll be hearing about this from **Fred Schaller, Ernie Kaswell, Aaron White, Paul Stanton** and **Seymour Sheinkopf**. Eventually each of us will be invited to respond. But until we get the official messages it might be helpful for us each to review our own careers to evaluate what our careers and accomplishments have actually been, versus what they would have been without the training each of us received from M.I.T. If our answers indicate the accounts need some balancing, we might each evaluate what we can contribute to enable the Institute to give help to the young people who are coming along so that they, in turn, can create their values, glamorous or mundane, for the world.

The mention of Nils and Janet Rosenberg, '40, at M.I.T. and Wellesley respectively, brings us to the anchor position for these '39 notes. Hilda and I were lucky to catch these travelers in Seattle and we spent several pleasant evenings at their Broadmoor home. Nils stays busy commuting around the world where he helps Boeing's customers optimize their training, maintenance, and operations programs. Jan has made four trips so far this year to Maui where they have a second home and where one of their daughters lives. — **Hal Seykota**, Secretary, c/o Birchall, 335 Second St., Atlantic Beach, Fla. 32233

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A Place In The Sun: The *New York Times* reports **George O. G. Lof** busy with solar energy development, both as director of the Colorado State solar laboratory, and vice president of Solaron, a company now producing solar heating and cooling systems for new homes. "There is a misplaced emphasis in a program that gives millions of dollars in grants to large, name companies or universities with no experience in solar energy to develop giant systems that are of no use to anybody," he says. . . . **Vladimir Hwoschinsky** is in his second year as process engineer at Hooker Chemical Corporate Engineering on Grand Island, N.Y. . . *Promotion*: Former deputy project director of a joint venture for the Metropolitan Atlanta Rapid Transit Authority, **Robert Seedlock** is now manager of the southern region (U.S.) for the international firm of Parsons Brincker-Hoff, Quade & Douglas, headquartered in New York City.

Number 6: Delta Psi's house, expanded and renovated, retains the charm of the 'number 6' club, and the fraternity has much thanks to give its building committee for the accomplishment. **Jack Danforth** chaired the committee.

Hail And Farewell: Deceased, in New York, May 24 last, **Robert O. Soman**. — **Frank A. Yett**, Secretary, 254 S. Euclid Ave., Pasadena, Calif. 91101

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Larry Turnock is Executive Vice President of the American Iron Ore Association. When he joined Republic Steel he had been with Pickands Mather and Co. and, previously, Technical Services, Inc., in Cleveland. . . . **Rogers Finch**, who became Executive Director of the American Society of Mechanical Engineers, was recently elected to the board of the American Society of Association Executives. This association represents 22 million persons and firms and has 5,300 members who manage associations in the U.S.A. and Canada. . . . **Harlan McClure**, dean of Clemson University's College of Architecture is a juror for the 1975 Architectural Awards of Excellence competition of the American Institute of Steel Construction. . . . **Walter Threadgill** is manager of design engineering in the Baton Rouge office of the Rust Engineering Co. Walter graduated in mechanical engineering and has over 33 years experience in the design and construction of industrial plants. . . . I had lunch with **Howard Samuels**, who is consulting with Proudfoot and is as energetic as ever. I didn't ask him if he thought he won by not becoming Governor of New York State. We have a standing offer — send in news, we'll print it. — **Henry Avery**,

Secretary, U.S.S. Chemicals, 2863 — 600 Grant St., Pittsburgh, Penn. 15230

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Greetings! I trust you enjoyed the holidays with a warm and cheery fire, some good skiing, a tropical cruise, or a well-deserved rest.

Bob Schwartz, owner of a plastics and lighting company in Oakland, was made chairman of the California (or northern California) Democratic Party. I have received no more details, but perhaps you could elaborate, Bob, for our next issue? . . . A brief note from **Bill Sadler** says, "I am now charging after my second graduate degree in systems management with U.S.C. at the Pentagon here in Washington. Recently spent two months in western Europe inventing my own Grand Tour with wife, who is chief librarian for Department of Defense in Europe."

A belated report of the death of **Edward W. Habicht,** 105 Cottonwood Dr., Williamsville, N.Y., on February 7, 1973. Ed was in course X, and did not complete his degree, but some of you will remember him.

And an update of **Andrew R. Buccini,** with whom I had a delightful lunch in Philadelphia a few short months ago. Butch is Vice President of Bakers Equipment/Winkler, Inc., Englewood Cliffs, N.J. And despite the recession, his company has been setting all sorts of sales records so he must be doing something right. Butch still lives in his lovely home in Richmond, Va. In his spare time, he flies a sailplane.

So that brings us up-to-date on a few classmates. Please write, wire, or call any news about you or about classmates you know. — **John L. Hull,** Acting Secretary, c/o Hull Corp., Hatboro, Penn. 19040

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Seventy-degree temperatures through early November made for a beautiful fall in the midwest — capped by my first eagle on a par-four since 1943. Weather and holes like that keep us golfers happy.

The news this month included the shocker that **Marty Phillips** died suddenly while on Institute business in Miami. More details were reported in the December *Review*.

In a more pleasant vein, **Percy Nelson** has been appointed Vice President of Chas. T. Main. In this position he is responsible for the design and administration of all steam power projects in the Pulp and Paper Process Division. Since part of this scope includes recovery boilers, he will also be responsible for environmental engineering. . . . **Fred Colusso** has been appointed Manager of Licensing–Europe for Combustion Engineering International. . . . **Bernard Morrill** has retired from Swarthmore College as the Turner Professor of Engineering. He plans to continue his efforts in support of minority education at both the college and elementary level. . . . **Edward Brandeau** has been appointed Manager of New Business Development at the Brand-Rex Co. in Willimantic, Conn. . . . **Carl Jenkins** writes that he is now with the Great Lakes Environmental Research Laboratory of the National Oceanic and Atmospheric Administration at Ann Arbor; he is the U.S. Coordinator on the International Field Year for the Great Lakes Program.

Had a pleasant lunch the other day with **Walt Ericsson** and compared some of our mutual frailties on the tennis court. Walt remains in charge of the A. G. McKee operations here in Cleveland and with only one son remaining in college can see the light at the end of the tunnel. Drop a line. — **Dick O'Donnell,** Secretary, 28516 Lincoln, Bay Village, Ohio 44140

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Jack Page is dividing his efforts between his consulting business and further developing of some successful oil and gas properties. I visited Imogene and Jack at their home in Dallas and enjoyed a fantastic chicken barbecue. Jack is completing a greenhouse for their many lovely plants, and Imogene has several of her beautiful sculptures in the house and on their patio. Their son Carter is a senior at Texas A & M, their younger son is a freshman at Vanderbilt, and their daughter is married and lives in San Antonio. Jack plays golf and has been sailing regularly at Lake Ray Hubbard north of Dallas.

On the same trip, while I was transferring between planes in St. Louis, there was **Bob Bliss** in the airport. He was returning from a week in the St. Louis area where he is working as the Midwest District Officer for the M.I.T. Leadership Campaign. Bob's appointment was announced by **Ken Brock** in August of this year. Bob will spend more than half his time in the Midwest working closely with area leaders in the solicitation of alumni, friends, foundations, and corporations who can make major gifts to the Campaign. After graduating in Course II, Bob had a distinguished career with U.S.M. Corp. interrupted for one year, 1958, when he was a Sloan Fellow and received his S.M. degree. At U.S.M., he began as Project Engineer and served as a Divisional Sales Manager, General Manager, Director of the Mechanical Laboratory, and, most recently, Planning Director. Throughout he has been an active alumnus — Downtown Boston Chairman for the Second Century Fund, Alumni Fund Regional Chairman, Reunion Chairman and President of our class, President of the M.I.T. Club of Boston and co-founder of the M.I.T. Club of Route 128.

Ferdinand G. von Kummer has been elected Vice President-General Manager of A. B. Dick Company's International Division after two years as Vice President-Research and Engineering. . . . **Elias J. Corey,** Sheldon Emory Professor of Chemistry at Harvard University has won the American Chemical Society's $10,000 Arthur C. Cope

Scheffer Lang: Most People's "Pet Ideas" About the Railroads' $4 Billion Problems Are Wrong

When most enterprises run out of money, unable to earn enough to pay their bills, they go out of business. "A logical outcome," thinks A. Scheffer Lang, '49 . . . except that it doesn't happen that way in his business.

Mr. Lang is Assistant to the President of the Association of American Railroads. Here are some observations he made when he returned to Cambridge last fall to describe the dimensions of the railroads' problems — and some possible solutions — at the weekly seminar luncheon of the Center for Transportation Studies.

In 1974 — it was, on average, a good year for the railroads — the cost of operating and maintaining the nation's rail system was $20 to $21 billion. But revenues were only $17 billion. Such shortfalls are chronic, he said, and the railroads' assets for meeting them are nearly exhausted. Given present attitudes and policies, there's "no escaping" increasing government intervention, he thinks.

There are in fact a series of options for balancing the railroads' books:

— Let carriers close down money-losing, little-traveled branch lines; the savings would be $100 to $150 million a year. (Or let government subsidies cover losses on these operations.)

— Fully reimburse the railroads for the costs of commuter and Amtrak passenger services, another $100 million a year.

— Pay grade crossing costs ($150 to $200 million a year) which the railroads now must cover even though their routes often predate the crossings.

— Make tax-exempt the fixed facilities the railroads use for transportation. Only pipelines among all other transit modes pay taxes on rights-of-way. For the railroads, the bill is $200 million a year.

The $600 to $700 million saved by adopting these policies, says Mr. Lang, is just the amount the major American railroads, omitting the northeastern lines which are now incorporated in Conrail, need to balance their books.

But this is a static solution for a dynamic problem, and the real need goes deeper — into the fundamentals of how America's transportation network operates. By this Mr. Lang meant labor work rules, the efficiency with which the railroads use capital and equipment, and subsidy policies. An example of complexities in the latter: if subsidies are ended and tariffs rise on interstate water transportation, the railroads may regain up to $500 million a year of income. Rail rates on routes parallel to inland waterways have been cut to meet the artificially-priced competition; rail rates would return to normal as soon as water rates go up, and volume would rise, too.

"Lots of people have their pet ideas" about why the railroads are losing money: inept management, past excesses, surplus fixed plant. "A bunch of baloney," says Mr. Lang. No single issue is adequate to explain the problem and no single solution to solve it. — J.M.

Award for 1976. Elias is one of the world's foremost organic chemists and is being honored for his "sustained record of contribution," particularly his syntheses of complex natural products and his pioneering work in the use of computer analysis for synthetic design. . . . **John G. Pulos** is presently assigned as Navy Science Adviser to the Commander, Operational Test and Evaluation Force, U.S. Atlantic Fleet, Norfolk, Va. . . . **John Farrow** is in Michigan working in plastics with Ford's Scientific Research Staff. John's wife is now a grandmother (2½ times), and she reminds John that he is also a grandfather.

Ross Bowen died in August when a fire destroyed his 225-year-old home in Epping, N.H. Ross was owner of Sentinelle Security Services located in Epping. Previously he had been associated with the paper industry for over 25 years while working with Cheney Bigelow Wire Work Co. in Springfield, Mass. Born in Brooklyn, N.Y., Ross became a staunch New Englander. He attended Kimball Union in Meriden, N.H., before M.I.T. (Course XV). His avocation was the restoration of the family's colonial farmhouse and bringing the woodlands to productive use. He was a member of the Society of Mayflower Descendents. Our class extends our sympathy to Ross's wife, Marjorie, and their three children. — **S. Martin Billett,** Secretary, 16 Greenwood Ave., Barrington, R.I. 02806

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It's a pleasure reporting special recognition of classmates, such as the 1975 David Sarnoff Award for Outstanding Achievement received by **George H. Stevens,** one of a team of four R.C.A. scientists, for outstanding contribution to the development of a multifunction tactical phased array radar system. . . . **Dave V. Ragone,** Dean of Engineering at the University of Michigan, is now a Fellow of the American Society for Metals. . . . **Peter J. Philliou** recently received a doctor of jurisprudence degree from Suffolk University, Boston. He is presently working for Scientific Energy Systems as a Systems Analyst on steam engine application and other energy systems. . . . **Anthony Stathoplos** has been appointed Director of Nuclear Safety by Power Systems Group of Combustion Engineering, Inc. Before joining C.E. in 1970, he was associated with United Nuclear Corp. and Nuclear Technology Corp.

Special Request: **Al Parr** was program manager in charge of the design, construction, and installation of Visual Trainers for the Lunar Missions. His interest has been strengthened by his experience helping to teach his son, Bill, who has a hearing impairment. Al is interested in visual learning, especially through cartooning. He would like names and addresses of similarly interested cartoonists. His address is 4 Beech Pl., Valhalla, N.Y. 10595.

Alexander J. Tachmindji is Chief Scientist of MITRE based in Washington. He will review MITRE's technology-based activities and help design and execute a program to increase and improve them. Alec was Deputy Director of the Defense Advanced Research Projects Agency and worked at the Institute for Defense Analyses as Director of the Systems Evaluation Division and Deputy Director of the Science and Technology Division.

Gordon Zucker and family are moving from Phoenix to Butte, Mont. He teaches at Montana College of Mineral Science and Technology, after serving as Engineering Manager of Siemens Corp. . . . **Rodwell V. Todd** has bought a clothing manufacturing business after 20 years in advertising. He is in the West Indies making resort and casual wear. . . . **Clinton B. Seeley** of Andover, Mass., hopes to finish building his home after 15 years' work. . . . **John P. Dowds** of Oklahoma City, whose company is engaged in oil and gas exploration, is President of his local M.I.T. Club and has been promoted to Colonel in the U.S.A.F. Reserve.

Vic Yancey is Chief Airframe Engineer in F-15 System Program Office, Aeronautical Systems Division at Wright-Patterson A.F.B. in Dayton, Ohio. He likes his work and two-year-old remarriage. . . . **John W. Nevins** is an associate of the consulting engineering firm Simpson, Gumpertz and Heger, Inc., Cambridge, Mass. He is Project Administrator of structural design projects, including hospitals and university buildings.

John W. Nevins, '51

Fafnir Bearing Co., a division of Textron, has promoted **Manfred E. Becker** of Newington, Conn., to Director of Product Engineering. He has been with Fafnir since 1953. . . . **Allan Elston** was recently elected Senior Vice President of Consolidated Food Corp. in Chicago. He will supervise the operations of a group of Consolidated's non-food divisions. His last position was with Pillsbury of Minneapolis as a corporate officer.

Stanford B. Jones has a new job as General Manager of Adams Equipment, Division of General Machine Products, Inc. of Trevose, Pa. Others in the industrial field are **W. R. Miller,** Vice President-Research and Development of American Sterilizer Co., Erie, Pa.; **George H. Fernald, Jr.,** Vice President of Polaroid Corp., Cambridge, Mass.; **Robert MacCallum,** Business Manager of Chromium, Manganese and Special Metals Department in the Metals Division of Union Carbide Corp.; and **Fiore DiGiovine** of Waltham, Mass., Corporate Director of Administration of Plymouth Corp.

Avrom R. Handleman of St. Louis manages a chemical forest fire control business for Monsanto. His wife recently finished law school and is now practicing law.

Anything you want to know about guns can be found in *Gun Data Book* by **F. Philip Rice,** published by Harper & Row. The publisher says: "The information is presented in a concise text and in over 100 tables, a compilation of gun data that will serve as a permanent reference for years to come." The author now lives, hunts, fishes, and writes books in Portland, Me.

We regret having to report the following deaths: **Curtis H. Snow** of 47 MacMillan Dr., Brunswick, Me., on August 18, 1971; **Richard D. Goss** of 24 Rockland St., Swampscott, Mass., on August 1, 1975; **Malcolm Basche** of 178 W. Ridge Drive, West Hartford, Conn., on June 25, 1975. He was a Senior Research Metallurgist at United Technologies. And **George R. Higgins,** Professor of Civil Engineering at the University of Massachusetts, of 81 Harlow Dr., Amherst, Mass., on June 22, 1975. — **Fred W. Weitz,** Secretary, 4800 S. W. 74th St., Des Moines, Iowa 50309

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Do you feel older? You should. Our 25th

Corporate Interest vs. Public Interest?

If you want an unbiased, highly qualified expert, where can you find him in America today? Most people turn to college campuses, expecting that academic standards and freedom assure high qualifications and independence.

Charles L. Schwartz, '52, Professor of Physics at the University of California (Berkeley), was skeptical. How real is the assumed independence of academic scientists who are influential in public policymaking, for example?

To approach an answer, Dr. Schwartz hypothesized two categories of academic people on the basis of corporate connections: Class A are scientists who are directors of corporations with annual sales or total assets over $100 million, Class B are directors of $10- to $100-million corporations or consultants to over-$100-million corporations.

Some results, as reported by Professor Schwartz in *Bulletin of the Atomic Scientists* for October, 1975:

— Of 78 members of the President's Science Advisory Committee during its 16-year history, 55 were "academics." More than half of them had Class A connections, another 15 per cent Class B connections.

— Of the 78 members of the National Science Board during the same 16-year period, 62 were "academics"; of these, more than one-third were Class A and over one-half were Class A or B.

Professor Schwartz concludes that "a majority of the elite academic science advisers have been captured by the large corporations. . . . The business of America is business, from which it follows naturally that the big decisions of government are shaped by the needs of big business," writes Dr. Schwartz, and he urges "a broadened search to bring to light the many still hidden corporate connections of scientists, engineers, and various other kinds of experts who assert that their work is in the public interest."

Reunion is nearly upon us. **Arnie A. Kramer**, Chairman for the reunion, is looking for interested classmates to help. In particular, Arnie would like area chairmen in cities all over the United States. Anyone interested in generating interest by phone contacts or otherwise amongst his living group, house group, or friends is encouraged to contact Arnie at 381 Peakham Rd., Sudbury, Mass. 01776; telephone (617) 443-9871. If a woman answers, it will be Mrs. Kramer. The nearly perennial bachelor, Arnie, was married a year ago this past June.

Our classmates in the academic community continue to do well. **Stephen J. Kline**, professor at Stanford University, won the 1975 Fluids Engineering Division Award of A.S.M.E. . . . **Darrell A. Frohrib** was recently promoted to full professor of mechanical engineering at the University of Minnesota. Professor Frohrib is responsible for design and graphics activities in the Mechanical Engineering Department. He and the University's Department of Neurology have developed an implantable fluid-pressurized device for the control of human incontinence, used in 275 patients to date. . . . **John J. McCarthy** is presently employed as a staff member in the Plasma Physics Group of the Research Laboratory of Electronics at M.I.T., where he has worked since 1945. . . . **James A. DiVito** notes that he is a senior engineer with New England Power Service Co. Jim is mainly engaged in all civil engineering aspects of new and existing power plants. He and his wife have seven children ages 9 through 22 — three boys and four girls. . . . **Mike Nacey** was elected Vice President of Bolt Beranek and Newman, Inc., in 1974. Bolt Beranek and Newman is a Cambridge-based company engaged in consulting, research and development. Mike's responsibilities include personnel administration, patents and licensing, and certain investments.

Captain **Chuck Mathews** (C.E.C., U.S.N.,) and his wife, four girls, cat and dog reside in San Diego where Chuck is Force Civil Engineer for Naval Air Force Pacific. . . . I recently visited **Ed Margulies** at his home in Highland Park, Ill. Ed is a general surgeon practicing at Highland Park Hospital. He and his wife Paulette, now have three children, Sarah, 4, Danny, 2, and Larry, 6 months. Ed left his associates some two years ago and is now much happier working alone, despite his long hours. . . . **Palmer S. Shannon** says that his firm, Communications Systems of Old Greenwich, Conn., recently received a contract to supply all production supervision for Jim Sant'Andrea, Inc. of New York City, a major producer of multi-media and film presentations. . . . The president of Satellite Systems Engineering, Inc., a small engineering firm in the field of satellite communications, is **Wilbur L. Pritchard**. Satellite Systems Engineering is located in Washington, D.C. — **Arthur S. Turner,** Secretary, 175 Lowell St., Carlisle, Mass. 01741; **Richard F. Lacey**, Assistant Secretary, 2340 Cowper St., Palo Alto, Calif. 94301

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Ari Miliotes turns his back on nuclear weapon analysis, computer programming, and corporate technical management to rest his ample frame on the counter of his deli in Clearwater, Fla. He adjusts his large white hat, tugs at his apron strings, and serves gourmet wine, cheese, and delicacies. For those hitting the west coast of Florida, drop in at the Countryside Mall in Clearwater and follow your nose to "Mr. Dunderbak's." That is Miliotes spelled sideways.

If you think Ari has escaped — toothless **Joe Bova** is no longer catching pucks in his mouth but ducking coconuts in Hawaii. . . . Also, **Bob Gardella** is cashing in on the waterbed boom as vice president of a foam rubber company in Marblehead, Mass.

Dean Jacoby recently visited the **Coley Bresee**'s in San Francisco while enroute to Japan for Polaroid. Coley is temporarily shelving his law practice in favor of teaching in the Golden State University Law School. Coley and wife Pat are active athletes: Pat participated in the A.A.U.'s senior swimming championship (over age 35), sweeping the pool in her events. Coley is a ranked tennis player — #17 singles, #8 doubles in Northern California.

Your class officers met in Lexington on November 5. Attending were **Wally Boquist,** President; **Dean Jacoby**, Vice President; **Joe Blake**, Class Agent; **Bob Evans**, Treasurer; **Bob Warshawer**, Chairman of 25th Reunion; **Dave Howes**, Secretary, **Chuck Masison** and **Lou Mahoney**, Assistant Secretaries. The most important item on the agenda was the class gift for our 25th Reunion. Several representatives from M.I.T. were present to assist us. They reviewed the critical need for funds at M.I.T. so that the Institute can maintain its standards and continue to attract the top students. You will be receiving a letter shortly from Wally Boquist and Joe Blake with regard to the Alumni Fund. **Bob Anslow** is our Class Gift Chairman and we will be looking for members of the class to assist him. Volunteer, anyone? — **E. David Howes, Jr.,** Secretary, Box 66, Carlisle, Mass. 01741; Assistant Secretaries: **Chas. Masison**, 76 Spellman Rd., Westwood, Mass. 02090; **Lou Mahoney**, 14 Danby Rd., Stoneham, Mass.

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The time has come for another column, and I've been eagerly awaiting your mail. But the only letters in the slot are a mortgage notice, a tuition bill, and a cemetery advertisement. Logical deduction leads me to believe this is not an organized protest, but rather a yearning for additional items from the 20th Reunion questionnaire.

The second section of the questionnaire addressed the topics of home and the family. The results show that we classmates are, to a great extent, models of the mainstream. Of those responding, 77 per cent live in suburbia, while six per cent are in an urban neighborhood, seven per cent in an exurban area, and ten per cent in a rural setting. Only five per cent found a question on mortgages not applicable; of the rest, 11 per cent had paid it off, and 84 per cent had not. The average annual personal indebtedness, excluding mortgage, is 31 per cent of annual income. The low for this category was zero, and the high was reported to be 500 per cent.

The questions on matrimony revealed the respondents to be pretty content with their situation. Five per cent never married; 79 per cent married once, 16 per cent twice, and there were no replies in the more than twice column. On the issue of marital bliss, 83 per cent checked the box for happy with present spouse. Only two per cent are actively looking for another, six per cent are bored but unwilling to change, four per cent have found other interests, and six per cent found the question inapplicable to their situation. The average number of children is three, and the average number of pets is two. One classmate listed all 79 animals on his farm as pets, but I find it hard to believe that he finds those cows and chickens entertaining every morning.

Family size, and its cause and control, was another topic. 59 per cent would, if starting again, have the same number of children; 17 per cent would have more, and 24 per cent would have smaller families. For 49 per cent the children were carefully planned. For 25 per cent the little dears were accidents, and for another 26 per cent they were the results of a gradual education.

The education of children is a topic rapidly coming into focus for most classmates. 96 per cent expect their children to go to college, and 63 per cent expect to pay all college expenses. In a ratio of 54 to 46, classmates would like at least one of their children to attend M.I.T. In terms of attitudes, 44 per cent expect their children to have similar ideals to theirs, while 47 per cent expect their children to be more liberal and nine per cent more conservative. By a nine-to-one margin, classmates did not have different expectations of attitudes for daughters than for sons. Thus the picture emerges of the happily married suburbanite with three not-too-carefully planned children who are college-bound at dad's expense. Send news. — Co-secretaries **Marc S. Gross,** 3 Franklin Court, Ardsley, N.Y. 10502; **Allan C. Schell,** 19 Wedgemere Ave., Winchester, Mass. 01890

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Save June 4 to 6 for our 20th reunion. It will be held on campus to take full advantage of Institute facilities, and will include an excursion and a special program for children. Come, have a weekend vacation at a bargain price, and visit with your classmates. Watch for details in the mail. Our class is expecting winners, like our guest at the 15th, Dr. David Baltimore, who just received the Nobel Prize in Biochemistry.

Roger Borovoy has been Vice President, General Counsel and Secretary for Intel Corp., Santa Clara, Calif., for the past year. Intel designs, develops, manufacturers and markets innovative products based upon integration of electronic functions on a small chip of semiconductor material. Roger has been involved in M.I.T. activities in the San Francisco Bay area over many years. He held several club offices during the 1960s and is currently on the Education Council.

Murray Gerber writes that his firm, Prototype and Plastic Mold Co., has moved to its fourth plant in Rocky Hill, Conn. . . . **Paul Jaenichen** is now a retired lieutenant colonel and is currently living in Brandenburg, Ky. . . . **Ted Korelitz** has returned from a special assignment for Badger in Holland. While there, he met **Jim Kellard**, who is with Fluor Corp. near Amsterdam. . . . **Bernard Kupferschmid**, Director of Opera-

Colby Chandler on How Profits Become Jobs

Colby H. Chandler

"The worst crime against working people is a company which fails to make a profit," said Samuel Gompers, the pioneer organizer in the American labor movement a century ago. Still true, thinks Colby H. Chandler, S.M.'63, Executive Vice President of Eastman Kodak Co., and he uses the quotation whenever he has a chance to remind audiences how far and how fast the U.S. has progressed "behind the engine of free enterprise."

At Eastman Kodak, says Mr. Chandler, retained earnings — "the dynamic part of profit" — are used to create new products with new tools and new machines. "And the best part about this investing in technology is that it doesn't do people out of their jobs. Quite the contrary," says Mr. Chandler: the result is inevitably more productive employees and more useful products for customers.

The nation's founding fathers 200 years ago had the same vision, thinks Mr. Chandler. He cites the words of Thomas Jefferson: "Agriculture, manufacture, commerce, and navigation — the four pillars of our prosperity — are the most thriving when left to individual enterprise." Clearly, he thinks, the framers of the Constitution "intended to set up a system that could include self-interest and harness it to useful purpose. To my mind, that still sounds like the most optimistic, the most revolutionary, and the most realistic experiment in self-government ever tried."

Mr. Chandler goes out of his way to talk about business and its opportunities whenever he can; he's convinced that "failure to understand practical economics can have unfortunate consequences for the nation, just as it can for individuals."

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tions for Harbridge House, Inc., a management consulting firm, attended the Alumni Officers' Conference. His wife, Gene, is coordinator of the Spanish language department at Boston College. . . . **Jay Silverston** is a principal in a new company, Xenergy, Inc., of Lexington, Mass., which analyzes each client's needs and recommends methods to reduce energy usage and costs in industrial, commercial, and public facilities. . . . **Raul Solorzano** writes that he is one-third partner in a consulting firm which provides civil and electrical services in Managua, Nicaragua. Raul is also head of the civil engineering department of Universidad Centro Americana. . . . **Christian Van Peski** writes that his company, Electromask, Inc., was purchased by T.R.E. — Cosecretaries: **Bruce B. Bredehoft,** Box 181, Dover, Mass. 02030; **Mrs. Lloyd Gilson,** 35 Partridge Road, Lexington, Mass. 02173

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The only news for this month is the notice of the Annual New York Area Class Cocktail Party. It will be on Friday night, February 6 in Hoboken, N.J. The cocktail party will be followed by an informal dinner at a local oyster house. This get-together is being arranged by **Ed Friedman,** who is Dean of the College at Stevens Institute of Technology. Last year's party was a great success, so please give Ed a call at (201-792-2700) or myself (212-977-8655) if you would like to attend. Ed is planning to contact classmates in the N.Y. and N.J. area. — **Fred Morefield,** Secretary, Apt. 6-A, 285 Riverside Dr., New York, N.Y. 10025

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A very thin mailbag over the last month. **Bill Towle** is with the Southeast Asia Regional Office of the World Health Organization where he serves as an overall consultant in planning and management in regard to W.H.O. and continues in the region, particularly Bangladesh, Nepal and Thailand. . . . **Ahmad Ali Kompany** wrote from Teheran, where he is a Specialist in the Technical Bureau of Iran Plan and Budget Organization, that he has recently been elected a Fellow in the American Society of Civil Engineers. . . . We also heard from Bruce Silberg, '60, that he had acted as volunteer librarian at the Association for Computing Machinery prior to the library's being moved. I can only infer from the postmark that this was somewhere in New Jersey. How about some other details, Bruce?

Jerry Schooler sent a letter from London where he is a Senior Lecturer in Management and Corporate Planning in the School of Business Studies at City of London Polytechnic. His major interest is in environmental health management and he also serves as a director of a charitable organization, the Public Health Advisory Service. Jerry noted that he and his England-born wife have recently bought a new home (though the house dates back to 1600) with a little land for growing fruits, vegetables and vines in an effort to combat the high inflation rate. . . . For those who may be curious as to **Dick Sampson**'s whereabouts, Jerry met Dick for a pub-lunch in London last summer. Dick is a bank investment counsellor specializing in the commercial banks for Loomis Sayles here in Boston.

Also in the Boston area, **Art Collias** has left his position with the Center for Advanced Engineering Study at M.I.T. to join American Science and Engineering in Cambridge as a sales engineer in the Marketing Dept. of their Industrial Systems Div. Art will be involved with their X-ray inspection systems of the medical type and those we pass our luggage through at airports.

That's all for now. Keep the cards and letters coming and we promise a column each month. It only takes a few minutes to drop a note to **Phil Richardson,** 180 Riverside Dr., N.Y. 10024; **John Amrein,** 770 Greenwood Ave., Glencoe, Ill. 60022; **Adul Pinsuvana,** 49 Seri Rd., Seri Village, Hua Mark, Bangkok, Thailand; **Bob Muh,** 907 Chantilly Rd., Los Angeles, Calif. 90024; and myself. — **Allan Bufferd,** Secretary, 8 Whitney Rd., Newtonville, Mass. 02160

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This month there are just two new notes and several earlier items to report. **Salomon Seroussi** writes that he has been a temporary resident of Ramat Aviv, Israel, for the past year. He is a systems engineer with I.B.M., and his specialty is communications. . . . **Tom Farquhar,** our class treasurer, is Vice President for Operations Research at Massachusetts Financial Services, where he is applying quantitative techniques to the investment process for mutual funds and private clients. Tom had been with Honeywell until 1969, when he joined Massachusetts Investors Trust, a forebear of his present employer.

Working our way back to mid-1974, we find half a dozen notes, including regards from **Walt Crewson** and **Roy Krupp.** . . . **Robert Gold** reports that he is in medical practice in Denver, and his specialty is anesthesiology. . . . **David Perry** indicated that he was completing his third-year residency in general psychiatry at the Upstate Medical Center in Syracuse. He was appointed an instructor at the medical center and a staff psychiatrist at the Syracuse V. A. Hospital in July, 1974. . . . **Bruce Johnson** was instrumental in organizing the First Bank of America in Colorado Springs and was serving as its president. . . . **Jaime De Sola** spent five years working in private

Being President of the M.I.T. Club of Boston is a big job — and sometimes a "fun" one, too. Here are Stephen Swerling, '63, and Mrs. Swerling visiting with Congressman Robert Drinan at the head table of the Boston club's fall dinner meeting; Mr. Drinan was the speaker.

commerce in Curacao before returning to Shell Oil in February, 1974, at which time he was transferred to Caracas with his wife and three children — Michael, Monica, and Sergio, then 8, 6, and 2, respectively. His new position was Manager in the Supply and Refining Administration, with responsibilities for the Area Model and Appraisal.

That's it for this issue. Let me reemphasize that to print news we have to receive news, and we would like to hear about you. To plagiarize the notes in another alumni magazine which I receive, "I'm completely out of news. Help." — **Robert F. Stengel,** Secretary, 152 Oxbow Rd., Wayland, Mass. 01778

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Robert H. Walker has been named Dean of College of Natural Science and Mathematics effective September 1, 1975. . . . **James W. Kesler** returned to Leesburg, Va. (103 N. King St., 703-777-5894) after four and one-half years in Germany with the U.S. Army. He is continuing to work as an engineer in various Army research and development programs. . . . **Steven J. Brams** tells us that his first book, *Game Theory and Politics*, was published by the Free Press of MacMillan in March, 1975; a second book, *Paradoxes in Politics: An Introduction to the Nonobvious in Political Science*, will be published by the Free Press in February, 1976. The books are in paperback — **Gerald L. Katell**, Secretary, Parking Structures International, 250 E. First St., Los Angeles, Calif. 90012

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Well, here it is, that time of month again for doing the old *Tech Review* column. I must say that I was a little discouraged as I sat down to my typewriter this morning. I had a column to do, and only one alumni fund envelope flap — not even a miserable press release or two. Surely this month's offering was going to set a record for brevity. Just then the telephone rang, and who should it be but **Larry Beckreck.** As I reported in this space last spring, the Beckreck's had moved to England after a three-year stay in San Francisco. Larry is working for an English firm, Genesys, in the civil engineering field. Larry's responsibility is international marketing, and he had just completed a swing through Brazil, Peru, Denver, and San Francisco. After three weeks on the road he was pretty tired and was glad to be heading for home. Larry passed on the news that Margie and **Larry Krakauer** are the proud parents of a baby daughter, Alicia, born in October. This is the Krakauer's first child, and both parents and child were reported to be doing well.

My other correspondent this month was **Ronald Eng Young.** Ron has worked for S. Ross and Co. and has lived in Belmont, Mass., since finishing up his doctorate (Aero and Astro) at M.I.T. five years ago. He reports that Lauren was born this past year, joining Evan, 3, and his wife Jean, a B.U. grad.

I can't believe that after only two and a half years of doing this column I have written all there is to write about the 700 or so members of the class of '63. I know that you're out there and that you must be doing something that would be interesting for the rest of us to read. Besides, my typing is going to get awfully rusty if I don't have this column to do once a month. — **Mike Bertin,** Secretary, 18022 Gillman St., Irvine, Calif., 92715

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Greetings to the Class of '64. A very joyous holiday season and a Happy New Year to you and yours!

There is not much news this month; the best way to have more reading about our fellow classmates is for some of you to write us news.

Richard Carpenter's family has now been increased with the birth of Douglas Robert Carpenter on August 27. Congratulations to the whole family. Dick writes that they are all doing fine.

More happy news: **Carole Lubin** was married in June to Albert Lown, who is with the Internal Revenue Service in Houston, Texas, where Carole is the Senior Systems Analyst for the City of Houston Health Department. . . . **Robert Hershey** was recently promoted to Principal Engineer at Booz, Allen Applied Research in Bethesda, Md., where his job is to lead consulting assignments in acoustics and operations research.

Joe Kasper is still working at TASC in Reading, Mass., where he is involved in navigation systems analysis and data base design. Joe also informs us that **Bill O'Halloran,** another '64 classmate, works at TASC. The Kasper's "kids are in kindergarten and nursery school." Joe also writes about their latest venture: "Flew with wife Pat in our small plane out to Grand Teton National Park, in August; made obligatory stop in Casper, Wyoming, trying to convince everyone there that city name is misspelled. It didn't work. There's a lot more country at 4,000 feet and 160 m.p.h. than at 35,000 feet, 600 m.p.h.," but it seems they really enjoyed themselves.

Your Secretary has had some unexpected "run-ins" with classmates. Discovered the name **Mike Monsler** on a door at the Washington, D.C., branch of S.A.I. one day while I was there. Wondering how many Mike Monslers there are in the world, I tracked down the Mike Monsler — you guessed it, our very own version. Recently transferred down here, Mike and Barb are presently experiencing the housing agony Marlene and I have been living with for four months now — trying to sell in Massachusetts and buy in Washington, at the very least a rather expensive proposition. Later the same day, believe it or not, I was looking up a number in the local Department of Defense directory. As if by magic, the book opened to a page with subheading "TOR." Somehow coincidentally the name Torrieri popped into my head. Sure enough, there he was; **Don J. Torrieri,** working at Naval Research Lab. He married Nancy a few years ago and she is expecting their first child soon.

Just for one last laugher — but strictly truth again — I hadn't seen Mike Monsler since that day in early October when I inadvertently found him at S.A.I. In November, I was on a business trip to Hughes Aircraft, Culver City, Calif., to visit **Robert G. Kurkjian** when there in line behind me to sign up for a visitor's badge was — of all people —

Too Much Energy, Too Soon

John P. Holdren, '65, is used to spreading his ideas. As Associate Professor in the Energy Resources Program at the University of California at Berkely — the only professorial appointment not associated with a department — he is responsible for the campus-wide teaching and research of energy related problems. The following is a condensation of invited testimony before a subcommittee of the Joint Committee on Atomic Energy of the U.S. Congress. It appeared in the July 23, 1975 New York Times *and is reprinted with their permission.*

The United States is threatened far more by the hazards of too much energy, too soon, than by the hazards of too little, too late.

The hazards of too much, which have been as widely underestimated as the liabilities of too little have been exaggerated, include diverting financial resources from compelling social needs, making hasty commitments to unproved technologies, and generating environmental and social costs that harm human welfare more than the extra energy improves it.

The idea that slower growth of energy use is better follows from several lines of reasoning.

First, rapid growth of energy use fosters expensive mistakes. The pressure of growth encourages the nation to seize any and all sources of supply that seem available. Some of these sources are overpriced, some will prove unreliable and even more expensive than anticipated, some will produce unexpected environmental and social burdens.

Second, even at slower growth rates, a point exists beyond which more energy can do more harm than good.

The relation of energy to well-being is two-sided. Through its productive application in economic-technological systems, energy fosters well-being; but the environmental and social effects of mobilizing and using energy can undermine well-being by means of direct damage to health, property, and human values, and by disrupting indispensable "public service" functions of natural systems (climate regulation, fertility maintenance, waste disposal, controls on pests and disease organisms).

Mounting evidence suggests that the United States is approaching (if not beyond) the level where further energy growth costs more than it is worth.

Third, conservation of energy can mean doing better, not doing without. The essence of conservation is the art of extracting more well-being from each gallon of fuel and each kilowatt-hour of electricity. There is enormous potential for improvement by raising efficiencies in homes, offices, transportation, and industry.

Other approaches to energy conservation could involve changes in individual behavior, and critics of conservation are quick to suggest that what is implied here is a return to a primitive existence.

In a society that uses 5000-pound automobiles for half-mile trips to the market to fetch a six-pack of beer, consumes the beer in buildings that are overcooled in summer and overheated in winter, and then throws the cans away at an energy loss equivalent to a third of a gallon of gas per six-pack, this "primitive existence" argument strikes me as nonsense.

Fourth, saving a barrel of oil is generally cheaper than producing a barrel. Reducing waste through higher efficiency makes more energy available for genuine needs, but at smaller cost than the alternatives of more mining, more drilling, and more power plants. In this sense, conservation is the cheapest new energy source.

John P. Holdren, '65

Finally, less energy can mean more employment. The energy-producing industries comprise the most capital-intensive and least labor-intensive major sector of the economy. Accordingly, each dollar of investment capital taken out of energy production and invested in something else, and each personal-consumption dollar saved by reduced energy use and spent elsewhere in the economy, will create more jobs than are lost.

By carving the fat from our energy budget and wisely applying these savings, we probably could hold United States energy growth between now and the year 2000 to 1 percent per year, instead of the 3 to 4 percent so widely forecast. If our goal is to maximize human well-being, accounting both for the benefits of energy use and the likely costs, we should not aim at more energy growth than this, and I believe we should even aim at less.

Mike Monsler again!

Guess that's the "whole nine yards" for this issue. When you make it to Washington, please track us down at 301-340-7373 in Potomac, Md. Marlene can tell you how to track me down in Arlington, Va., during business hours. Write, please write! — **Steve Schlosser,** Secretary, 12401 Bobbink Court, Potomac, Md. 20854

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This month's column is very short. Next month's may be shorter unless you write!

Henry Lichstein writes to say that he, Janine, Daniel (4) and Alexander (2) are off to Nairobi, Kenya, where Henry will be the regional treasurer for Citibank in Africa. . . . **Jim Pearson** received an M.B.A. from the University of Chicago in August. For the past three years Jim has been working as a Materials Scientist at the Brunswick Corp. . . . Suzy and **Greg Schaffer** moved to Del Mar, Calif. They are active with the Scottish Dance group in San Diego, and enjoy the southern California beaches and mountaineering. . . . **Howard Ellis** is President of Enviroplan, Inc. In that capacity he is a consultant to the U.S. Environmental Protection Agency on air pollution regulations, to state governments on environmental impact statements for new highway projects, and to the electric power industry.

Bruno, our 8-year-old St. Bernard, is thriving. Please write. — **Edward P. Hoffer,** Secretary, 12 Upland Rd., Wellesley, Mass. 02181

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John Riordan sent the following letter: "After eight years I've finally got some worthwhile news for the class notes. For the last four years I've been working on a Ph.D. in plasma physics at the University of California, Berkeley. Hopefully, I'll finish in a year or so. This summer I teamed up with Steve Dreher, '69, Peter Lehman, '66, and Carolyn Polese for a 550-mile canoe trip down the Thelon River in the Canadian Arctic. Our days centered around covering enough miles to get out before winter, and keeping ourselves well fed and sufficiently rested. The river and winds were much less cooperative than we expected, and the trip turned out to be the most arduous (physically and emotionally) experience of my life. Nonetheless, being completely self-sufficient in a strange land for six weeks was rewarding. Despite their name, the Arctic Barrens provided us with a caribou migration, a grizzly bear attack, great fishing, exciting rapids, and lots of unpredictable weather. I also gained a greater appreciation for the works of civilization and culture, which I avidly consumed upon my return."

Barry Watkins is a third-year law student at Boston University Law School. . . . A phone call from **Bob Howard** provides most of the news this month. Bob is still living in Miami where he is treasurer of his company. Unfortunately the name of the company escapes me. Bob gave me the following information: **Mike Frye** is living in London after a couple of years in South Africa. He is in charge of overseas manufacturing for an international company. . . . **Louis Offen** and Laura Rosenstock were married November 15, 1975. Louis is doing his residency at Jackson Memorial Hospital in Miami. . . . **Eric Coe** is a cardiologist in Leesburg, Fla. . . . **Steve Alter** has his Ph.D. from M.I.T. and is teaching in the U.S.C. Graduate School of Management. . . . **Mike Telson** is in Washington, D.C., as an energy advisor to the House Ways and Means Committee. . . . **Bruce Greenwald** is completing his Ph.D. in Economics at M.I.T. while teaching economics at Wesleyan. . . . **Rich Bronowitz** is a civilian working for the Navy in Washington, D.C. He has two daughters. — **Jim Swanson,** Secretary, 669 Glen Rd., Danville, Calif. 94526

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Only a few short items this month, so keep

those cards and letters coming, folks!

First we report recent graduations. **Rich Adelstein** has finished a law degree and a Ph.D. at Penn and is now Assistant Professor of Economics at Wesleyan University in Middletown, Conn. . . . Last June, **Richard Munson** was graduated from Downstate Medical Center in Brooklyn. He is now a resident in pyschiatry at Kings County Hospital in Brooklyn.

Far above Cayuga's waters, **Stan Humphries** has been made Assistant Professor in the applied physics department at Cornell. His current research centers on the development of intense pulsed ion accelerators for controlled fusion applications.

We've received a note from **Dan Asimov** who wonders if anyone in the class has his copy of *Geometry and the Imagination* by Hilbert and Cohn-Vosson; he remembers lending it back in 'tute days, and would like it back now. His address is: School of Math, I.A.S., Princeton, N.J. 08540. — **Gail** and **Mike Marcus,** Secretaries, 2207 Reddfield Dr., Falls Church, Va. 22043

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Alright, sports fans, here's the latest: Captain **Ronald L. Bagley** was cited for meritorious achievement as a member of a special studies group with the 17th Defense Systems Evaluation Squadron, a unit of the Aerospace Defense Command. Congratulations. . . . **Lee R. Brettman,** M.D., writes that he is doing a second year medical residency at University Hospitals of C.W.R.U. in Cleveland. . . . Recently promoted to a position with Honeywell's North American Operations Law Office as Counsel is **David A. Frank.** David is relocating to Phoenix to work with the company's computer operations. . . . **Talal A. Kheir** is employed by the architectural and structural engineering firm of Jordan/Casper/Woodman/Dobson. Talal is designing cranes, shipping structures and anything else that needs to "stand on its own feet." . . . **Dale Larson,** an assistant professor of mathematics at Indiana University in Bloomington, writes to inquire if I remember him as the "Senior House hockey puck." How could I forget? As I remember it, the line of Larson, Kaplan, and Berliner (when he moved up from defense) wreaked havoc on intramural goalies for a number of years. Hope you're still playing hockey, Dale, I am. Dale received his Ph.D. from U.C.L.A. in the summer of 1975 and is spending this year as a research associate at Oxford (England) University.

Thomas Linkas has been named an assistant vice president of The Putnam Management Co., Inc. Tom was formerly a security analyst assigned to monitor the chemicals, photography, aerospace, business services, electrical equipment, and textile industries. Putnam manages stock funds and money funds. . . . **Michael J. McNutt** began his first year as assistant professor of electrical engineering at the University of Illinois in the autumn of 1975. . . . According to an incomplete clipping **Michael H. Murray** has apparently received a silver medal from the Massachusetts Association of Certified Public Accountants. Nice going. Michael is with Arthur Andersen & Co. in Boston. . . . **Thomas Najarian** writes that he will be completing his medical residency in July, 1976. His wife Sina is beginning her fourth year at Cambridge's Buckington-Browne & Nichols School. Children Nova and Mark are in good health.

Mark A. Rockoff has completed two years of pediatric residency at Massachusetts General Hospital and has commenced an anesthesia residency at the same institution. Mark plans to specialize in pediatric intensive care. . . . **Don Vawter** received his Ph.D. in August from the University of California, San Diego. He is currently a senior scientist at the University of Virginia in Charlottesville in the Department of Biomedical Engineering. His work centers on pulmonary mechanics.

Think snow. — **Peter Peckarsky,** Secretary, 950 25th St., N.W., Washington, D.C. 20037

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Our class reunion is coming soon, June 3 to 6, and the place has not been determined. If any of you have any ideas, and if anyone in the Boston area would like to work on the reunion please write Joseph J. Martori, Director for Alumni Services, E19-438, M.I.T., Cambridge, Mass. 02139. As of this writing (Nov. 1) no one has done any work on the project. We need help!!

Donald Haurin has joined the Ohio State University faculty to teach public finance in the Department of Economics. His wife, Jean, is a research assistant at Ohio State and is working on her M.A. in social gerontology. . . . **Raymond Kwasnick** married Susan Birnbaum of Newton, Mass., an art teacher. Raymond is starting his second year of law practice at the firm of Widett & Widett in Boston. He's playing football with Norm Mazer, '74, on the Fenway House (successor to SAM) C league team. . . . I appreciate the response that some classmates have been giving by writing some great letters. **Jack R. Hiatt,** 10130 Parkwood, #5, Cupertino, Calif. 95014, wrote a long letter: "I want to thank all my classmates that have inquired about my health over the past few years, especially Glowienka (since he was the only one). After leaving M.I.T., I ventured to California to attend Stanford Business School, and in California I remain. I live on the San Francisco peninsula, and find the world here agrees with me quite well. I currently am working for a computer company (time-sharing) as manager of a consulting group." Jack asked if anyone knows where **Dave Cartwright** and **Glowienka** are. He also said that Fred Horr, '72, is in Los Angeles doing who knows what for a government (D.O.D.) contractor; **Steve Rock** is back at school (Stanford) for a Ph.D.; **Jack Malarkey** works for Bechtel in San Francisco; **Larry Prior** lives on a farm in Indiana, Rich Lefebvre, '72, works for H. Ross Perot in South Carolina, and Scott Holden, '74, is still in the Boston area."

I had a good visit with **Chris Brewster** who has completed his work at the Harvard Business School and is now assistant to the president of GeoSource, an oil company in Houston, Texas. Henry Joseph, '74, writes: "I am living in Cambridge and working in construction. I am currently running a project which is converting a convent into subsidized congregate housing for the elderly. I am also involved in other efforts to preserve the existing housing stock in Cambridge, which is increasingly threatened by developers with plans to build high-rise condominiums. I often see Mark Marinch, '72, who, together with Alice, has founded the M and M Trucking Co., which provides trucking services for construction projects and food cooperatives in the Cambridge area. It's a thriving business which Mark plans to expand as soon as he can raise the capital."

Frank Taylor, 916 Graduate House West, W. Lafayette, Ind. 47906, writes: "I have almost completely lost contact with everyone I knew at M.I.T. Two years ago, on vacation from my job as laboratory assistant in biochemistry at Princeton, I drove to Los Angeles where I saw Bob Armstrong, '70, and Nancy, and Karl Overbeck, '68. While in Boston I saw **Chris Brewster** and John Dieckmann, '73, who was working on some kind of mine engineering for a small consulting company. About two years ago I was at **Ed Buchak**'s wedding, and I once had a couple of beers with Joe Thrift, '68 when he was in Princeton on business. I have not

A seminar on "International Safeguards for Nuclear Power" was a major fall activity of the M.I.T. Club of Washington. Here Congressman Mike McCormack (left) confers with three officers of the Club as the session in the Caucus Room of the Cannon House Office Building was about to begin: Mark Joseph, '64, President; Paul Polishuk, '71, Vice President; and Achilles G. Adamantiades, '66 (right), Treasurer, who was in charge of arrangements for the day.

heard or seen any of these people for the last two years and would have little idea how to reach most of them. As for me, after working in Princeton for three years, I have entered graduate school in chemical engineering, specializing in biochemical engineering, at Purdue University. I applied to 20 schools and chose Purdue because it made the best financial offer and because it has a good program in biochemical engineering. My master's research will be concerned with enzymatic hydrolysis of cellulose to sugar. I managed to save some money from my Princeton job and my dorm room is cheap so I should be able to live reasonably well (for a grad student). I also still have the '64 Corvair which I have been 'fixing' for the last four years. I think by now I have replaced nearly every replaceable part as well as doing a lot of body patching and repair. If I can just get it painted, which I have been thinking about but never done, I should have a fairly decent machine."

For those of you who know him, I got a long letter from "Jolly" Roger Smith, '73, who is alive and well at graduate school in Ohio (where else?) . . . I really appreciate the long letters I have received and ask for anyone to please write and I'll put it in the *Technology Review*. — **Hal Moorman,** Secretary, 3461 McFarlin, Dallas, Texas 75205

72

Here we are in 1976. The kids who graduate this year weren't even at the Institute when we were undergraduates. But, take heart dear classmates, we seem so far to be retaining (in most issues) our ever more tenuous place on the last page of the class notes, so it can't have been that long.

Wendy Erb, '73, writes, "Last year of Law School finally! I spent a most enjoyable summer in Denver, so-so as a town but the mountains are so close that it's great. I climbed eight 14,000-foot peaks. I'm working part-time for a San Francisco firm which is enjoyable. Talked to **Kathy Kram Dobkin** recently as she was moving into her New Haven apartment to start work on her Ph.D. at Yale. I'm hoping to see less of the hospital this year after a car accident and an emergency appendectomy in the space of a week at the end of May, which required five days' confinement." . . . **Thomas Flanagan,** is a Navy lieutenant serving on the *U.S.S. Whale,* a fast attack nuclear submarine. . . . **Bob Ellis** took the Ohio bar exam last July and is with a small firm in Lorain, Ohio. . . . Robert Ebert, '73, reports, "I spent a year as an R.A. for Dr. Richard F. Thompson, the well-known physiological psychologist, at Harvard (neurolinguistics, etc.), a year working on psycholinguistic research with Bill Cooper at the blessed Institute and am finally starting a Ph.D. program at the University of Wisconsin in Madison in clinical psychology (heavy on research). I still play a lot of clarinet and still sit zen."

Gus Dias Carneiro writes from Rio de Janeiro, "I left First National City Bank of N.Y.'s Rio office in August where I was corporate credit manager in their local investment bank, and am now working in a development bank partly owned by the state government. I do corporate planning which is fun, but not as interesting as the first-line job I had, out on the field contacting corporations. Summer is approaching down here and we bought a new apartment on a ten-year mortgage (Brazilian-style, with variable interest, equal to the wholesale price index plus a fixed spread). We are still four blocks from Ipanema beach, which is quite pleasant, since you can go swimming from 6:30 to 7:30 and still get to work by 9:00. Now we have two kids, a girl Ana Cecilia who is 1½, and a boy Carlos Henrique who is five-months-old. Carmen is working for her master's in urban planning at the Federal Univrsity here, and plans to be back in the U.S. late this year for graduate degrees. Who knows where, though? As you can see, things are going quite smoothly here. Tell our classmates to get in touch when they're around Rio." — **Dick Fletcher,** Secretary, 135 West St., Braintree, Mass. 02184

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Well, here we go again. Not much this time — it's the slow season, you know.

I received a letter from our class vice president, **Van Dunn**. Here are some excerpts from that exciting communication: "I attended my sixth Frosh-Orientation picnic. I've decided that I must attend the first ten Frosh picnics and maybe I will get a bid. . . I worked at Cornell Med this summer and I found out that I really like New York City. I didn't believe it at first, but there is just so much you can do. . . In closing, about 20 to 30 people from our class who did not get rings have expressed interest in getting the Brass Rat. I don't know if you mentioned this in your column yet, but if there are others who would like to get one, then I will get the rings."

Cyril L. Bruno writes: "U.C.L.A. has been quite a change from M.I.T. I should graduate in June, 1976 as a structural engineer — switched to civil engineering. Love that concrete." . . . **Elizabeth Anne Newton Hsu** is a first year medical student at the Medical College of Pennsylvania.

This may seem short — that is because it is. — **Dennis Dickstein**, Secretary-Treasurer, 16A Forest St., Apt. B1, Cambridge, Mass. 02140

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The Adams Chronicles has been made possible by grants from the National Endowment for the Humanities, The Andrew W. Mellon Foundation, and Atlantic Richfield Company.